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The USDA/ERS Computable General Equilibrium (CGE) Model of the United States

Sherman Robinson
Maureen Kilkenny
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Abstract

This paper documents the basic Computable General Equilibrium (CGE) model of the U.S. economy developed at the Economic Research Service (ERS), USDA. The paper both describes the model equations in detail and how the model is "benchmarked" to a base data set. The paper also lists the computer program used to implement the model. The objective of the CGE work program at ERS is to provide a multisectoral framework for analyzing the effect of changes in agricultural policies and exogenous shocks on the farm sector, on the rural economy, on related nonagricultural sectors, and on the rest of the economy. The basic model has provided a starting point for a variety of extensions and applications exploring a number of policy issues. To date, work has largely focused on issues of agricultural trade policy and the effect of alternative domestic policies.

Keywords: Computable general equilibrium (CGE) model of the U.S. economy, social accounting matrix (SAM) of the U.S. economy, and GAMS modeling software.

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Introduction

This paper documents a basic Computable General Equilibrium (CGE) model of the U.S. economy emphasizing agriculture and international trade.[1] Different versions of the basic CGE model have been used at the USDA to investigate a number of policy issues. To date, work has focused on issues of trade policy. A 10-sector version of the model has been used to analyze the impact of different proposals for liberalizing domestic and border policies concerning agriculture that have been suggested as part of the current negotiations in the Uruguay Round (1986-90) of the General Agreement on Tariffs and Trade (GATT).[2]

An early version of the model was also used to analyze the impact on the structure of the U.S. economy of macro shocks in the 1982-86 period by Adelman and Robinson (1988). A different version of the same model was also used to analyze the impact on the economy of cutting defense expenditures by Roland-Holst, Robinson, and Tyson (1988). Work underway at the International Trade Commission to develop an in-house CGE modeling capability starting from the USDA model is discussed in Roland-Holst and Tokarick (1989).

Work is underway at the USDA to expand the model to include more sectoral detail and to extend the specification in new directions.[3] The objective is to provide a multisectoral

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[1]The model was developed at the Economic Research Service (ERS), U.S. Department of Agriculture (USDA). Work on the model was part of the Intersectoral Policy and Performance Project in the National Aggregate Analysis Section, National Economy and History Branch, Agriculture and Rural Economy Division (NAA/NEH/ARED).

[2]See Robinson, Kilkenny, and Adelman (1989) and Kilkenny and Robinson (1988, 1990). For surveys of other analyses of agricultural trade liberalization using CGE models, see Robinson (1990) and Hertel (1990).

[3]These extensions are discussed below.

framework for analyzing the impact of changes in agricultural policies and exogenous shocks on the farm sector, on the rural economy, on related nonagricultural sectors, and on the rest of the economy.

The USDA CGE model is part of a long tradition of CGE models of the United States. These models focused on issues such as public finance, energy, industrial trade, the impact of import quotas, and the costs of pollution control. Examples include: Ballard, Fullerton, Shoven, and Whalley (1985); Hertel and Tsigas (1988); Hudson and Jorgenson (1974); Shoven and Whalley (1984); de Melo and Tarr (forthcoming); Goulder and Eichengreen (1989); and Jorgenson and Wilcoxen (1989).

A variety of approaches have been used to implement CGE models. The USDA model is implemented using a software package called GAMS (General Algebraic Modeling System).[4] The GAMS software represents an important advance in implementing CGE models because its algebraic language provides a concise way to specify model equations. The GAMS program provides complete model documentation, and the model specification is independent of the solution algorithm. In the past, modelers developed their own application-specific software, which made the models difficult or impossible to transfer to others. A CGE model written in the GAMS equation language can be run on a wide variety of computers, including PC's.

The next two sections provide a brief description of the CGE model and its overall structure in a social accounting framework. A complete description of the model equations is presented in the section following these two sections. We then discuss how the model is calibrated using data from a balanced Social Accounting Matrix (SAM) for the U.S. economy, and describe how we implement the model in the GAMS software. Finally, we discuss applications, variations, and alternative model specifications.

Major Features of the CGE Model

A CGE model simulates the working of a market economy in which prices and quantities adjust to clear markets for products and factors. The model specifies the behavior of optimizing consumers and producers in the market economy. It also includes the government as an explicit agent (although not an optimizer) and captures all transactions in the circular flow of income.

The model is constructed to focus on issues of international trade and incorporates imperfect substitution between imports and domestic goods in demand. There is a parallel treatment of export supply, with imperfect transformability between production

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[4]The GAMS package is described in detail in Brooke, Kendrick, and Meeraus (1988). The first CGE model implemented in GAMS was a model of Cameroon described in Condon, Dahl, and Devarajan (1987).

for domestic and foreign markets at the sectoral level. These features are characteristic of a large number of CGE models applied to developing countries to study issues of structural adjustment.[5] The theoretical properties of this model with "semitradables" have been extensively documented, and it can be seen as an extension of the Salter-Swan "Australian" trade model, which incorporates nontraded goods.[6]

This treatment of exports and imports realistically insulates the domestic price system from changes in world prices of sectoral substitutes. The model also makes the "small country" assumption on the import side, assuming that the United States cannot affect world prices of its imports. On the export side, we assume downward sloping world demand functions for some U.S. agricultural commodities. All other exports have fixed world prices.

Each sector produces a composite commodity that can be transformed into an export or a commodity sold on the domestic market. Each industry's output is produced according to a production function which uses primary and intermediate inputs. Sectoral input demands are derived from first order conditions for profit maximization.

Two modes of market behavior for primary factors (labor, capital, and land) may be modeled. In a "shortrun" version, capital is assumed to be sectorally fixed, and the final equilibrium will have sectorally differentiated rental rates. In a "longrun" version, all factors are mobile and average factor returns adjust to clear factor markets with full employment.

Aggregate domestic demand in the model has four components: consumption, intermediate demand, government, and investment (including inventory change). Household expenditure functions are derived from utility maximization. Each household pays income taxes to the government and saves a proportion of its income. Intermediate demand is given by fixed input-output coefficients. For the government, aggregate real spending on goods and services is exogenous. Inventory demand by sector is a fixed proportion of domestic output. The model distinguishes fixed investment by sector of destination and demand for investment goods by sector of origin. Investment demand by sector of origin is translated from investment demand by sector of destination by using a capital composition matrix.

The CGE model includes the major macro balances: savings-investment, government deficit, and the balance of trade.

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[5]For surveys of this literature, see Robinson (1989a,b) and de Melo (1988). There are also a number of multi-country CGE models. For a survey, see Shoven and Whalley (1984).

[6]See Salter (1959), Swan (1960), and Armington (1969). The properties of this approach are explored by Dervis, de Melo, and Robinson (1982); de Melo and Robinson (1981, 1985, 1989); Devarajan, Lewis, and Robinson (1990); and Brown (1987).

Aggregate investment is either set exogenously from a macro model or is "savings driven." Aggregate savings is the sum of enterprise-retained earnings plus capital consumption allowance, household saving, government saving, and foreign saving. Government saving is the difference between revenue and spending. Alternative approaches to reconciling aggregate savings and investment are discussed below.

In the balance of trade equation, the value of imports at world prices must equal the value of exports at world prices plus foreign savings, net remittances, and net foreign borrowing by the U.S. Government. Two alternative equilibrating mechanisms are possible. First, the balance of trade is specified exogenously and the real exchange rate adjusts to achieve equilibrium. Second, the exchange rate is exogenous and the balance of trade is assumed to adjust.

The CGE model solves only for relative prices. We choose as the numeraire price index the GNP price deflator. Given the choice of numeraire, the model solves for all relative factor returns and prices that clear the markets for factors and products. The model also solves for the equilibrium value of the real exchange rate, given the exogenously set balance of trade.

SAM Structure of the Model

A Social Accounting Matrix (SAM) provides a tabular snapshot of the economy at one point in time. Figure 1 presents a descriptive SAM for the United States that shows the transactions among agents in the economy captured in the CGE model.[7] The structure of the SAM is consistent with the U.S. National Income and Product Accounts (NIPA). The treatment of exports as a delivery from activities to the rest of the world, rather than going through the commodity account, reflects the model's specification of producers as "transforming" goods for delivery to the domestic and export markets. This treatment has the added advantage of making the commodity account in the SAM measure the trade-theory notion of "absorption," or total supply of goods to the domestic economy.[8]

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[7]For an introduction to Social Accounting Matrices, see King (1985) and United Nations (1968). The seminal work was done by Richard Stone and is described in Stone (1986). Pyatt and Round (1985) provide a number of examples of the uses of SAM's. Hanson and Robinson (1989) provide the mapping for the United States from the NIPA to a SAM framework.

[8]In the U.S. input-output accounts, exports are part of the commodity account. A "make" matrix is used to transform activities to commodities, with all intermediate and final demands (including exports) specified as demands for commodities. Our treatment, separating export and domestic demand, is consistent with our modeling perspective.

Figure 1--A Descriptive Social Accounting Matrix (SAM)

RECEIPTS OR INCOME	EXPENDITURES OR OUTLAYS									
	1	2	3	4	5	6	7	8	9	
	Suppliers		Value added		Institutional actors					Row
	Commodity	Activity	Labor	Capital	Enterprise	Household	Government	Capital	World	totals
Suppliers										
1 Commodity		intermediate demand				household consumption	government purchases	investment		domestic sales
2 Activity	domestic supply						export subsidies		exports	total sales
Value added										
3 Labor		employee compensation								employee compensation
4 Capital		capital income								capital income
Institutional actors										
5 Enterprise				gross bus. income			transfers to bus.			enterprise income
6 Household			labor income		distributed profits		transfers		net foreign remittances	household income
7 Government	tariff	indirect tax	social security tax		business profit tax	household income tax			net foreign transfers	government income
8 Capital					bus. savings +depreciation	household savings	government savings		net foreign savings	total savings
9 World	imports									foreign income
Column totals	total absorption	total costs	employee compensation	capital income	enterprise expenditure	household expenditure	government expenditure	total investment	foreign expenditure	

Each nonzero cell in the SAM represents the value of an economic transaction between actors. The model equations describe every entry in the SAM. The accounts in the SAM effectively define the transactions and income flows among five basic actors in the economy: suppliers/enterprises, households, government, capital account, and rest of world. A row documents the income to an account, the corresponding column documents the outflow, and the row and column sums must balance for each account. In equilibrium, this balance implies: (1) costs (plus distributed earnings) exhaust revenues for producers, (2) expenditure (plus taxes and savings) equals income for each agent in the model, and (3) demand equals supply of each commodity.

The first two rows and columns of the SAM capture the workings of the product and factor markets. The row of the commodity account describes the domestic product market, with the supply to domestic users. The column of the commodity account keeps track of absorption, which equals the value of domestic products sold on the domestic market, and imports, including tariffs.

Column two describes the demand for factors of production and intermediate inputs. Producers pay out value added to factors and indirect taxes to government down the column, and sell goods on the domestic and foreign markets along the row. Export subsidies are seen as a payment by government to producers. Exports and imports in the account for the rest of the world are valued in world market prices times the exchange rate.

The next two rows and columns (3 and 4) describe the payment of value added to primary factors and its distribution to institutional actors. The last five rows and columns (5 to 9) describe inter-institutional transfers and the generation of demand for goods in the product markets. The last three accounts (7 to 9) capture the major macro balances: government deficit, savings-investment, and balance of trade.

Three types of transactions occur among the actors. First, there are "market transactions," with goods and services (including factor services) flowing from rows to columns and corresponding payments flowing from columns to rows. These are given in the first two rows and columns of the SAM plus the last row and column. Second, there are "transfers," either voluntary or involuntary, involving nominal flows from column accounts but no real flows from the row accounts. Accounts 3 to 7 involve this type of transaction, essentially mapping the flow of funds in the economy. Tax payments can be viewed as involuntary transfers, while the rest can be seen as voluntary.

Finally, there are "financial transactions." In the SAM, these are all captured in the single "capital" account, which summarizes the workings of all financial markets. This account collects savings from the various actors along the row and uses the proceeds to purchase capital goods ("investment") in cell (1,8). In the capital account row, agents presumably receive title to assets in return for depositing their savings. Financial transactions in the capital account implicitly define

the market for new assets, with the supply of new assets equaling the value of aggregate investment. The CGE model, however, is defined only in terms of flows and determines a flow equilibrium for a single period. The model has no assets, money, interest rates, expectations, or dynamics.

Equations of the CGE Model

The order of the presentation of the equations follows the generation and flow of income from producers to households. First, we present equations defining the price system, followed by equations describing production and the generation of value added. The next block of equations describes the mapping of value added into institutional income. The following block completes the circular flow, describing the demand for goods by the various actors. Finally, there are a number of "system constraints" that the model economy must satisfy. These include market-clearing conditions and macro "closure" equations. A summary table of all the equations is provided in Appendix 1.

In the basic model, the U.S. economy is disaggregated into 10 sectors. There are three primary factors of production, three categories of households, and three "institutions" which serve as intermediaries in mapping factor income to household income. Table 1 lists the various indices, describes the sets they represent, and presents the definitions of all variables and parameters. Tables 2 through 6 list the model equations as they are described. Following the equation number in these tables is an index, or number, for counting equations. The counting of equations and variables is tabulated in table 7.

GAMS notation is used throughout this section. While close to standard algebra, GAMS has some differences. There are a few differences in operator notation. The summation operator is written "SUM," with the index of summation and the arguments written in parentheses separated by a comma. For example: $\Sigma_i X_i$ is written SUM(i, X(i)) in GAMS. The product operator is "PROD," and the algebraic expression $\Pi_i X_i$ is written PROD(i, X(i)). The GAMS language allows a great deal of flexibility in describing equations, including inequalities and Boolean relationships. We do not need these extensions in the presentation of the basic model equations. Some are used in the listing of the GAMS version of the model given in Appendix 2.

Some notational conventions are followed consistently. Endogenous variables are presented in upper case, while parameters, exogenous variables, and indices are always lower case. In a few equations, an index is replaced by a specific entry (given in quotes).

Table 1--Definitions of indices, variables, and parameters

	Indices
i, j	Sectors
im	Sectors with imports
imn	Sectors without imports: im + inm = i
ie	Sectors with exports
ien	Sectors without exports: ie + ien = i
ied	Sectors with world export demand functions
f	Factors of production: labor, capital, and land
ins	Institutions: labr, prop, and ent (Labor, property, and enterprises)
hh	Households
	Variables
Prices block	
EXR	Exchange rate
P(i)	Price of composite good
PD(i)	Domestic sales price
PE(i)	Domestic price of exports
PINDEX	GNP deflator
PK(i)	Price of a unit of capital in each sector
PM(i)	Domestic price of imports
PVA(i)	Value-added price
PWE(i)	World price of exports
PX(i)	Output price
Production block	
E(i)	Exports
FDSC(i,f)	Factor demand
INT(i)	Intermediate input demand
M(i)	Imports
WF(f)	Average factor price
X(i)	Composite goods supply
XD(i)	Domestic output
XXD(i)	Domestic sales
Income and expenditure blocks	
CD(i)	Final demand for private consumption
DEPRECIA	Total depreciation charges
DK(i)	Fixed investment by sector of destination
DST(i)	Inventory investment by sector
ENTSAV	Enterprise savings
ENTTAX	Enterprise tax revenue
FBOR	Net foreign borrowing
FXDINV	Fixed capital investment
FSAV	Foreign savings
GD(i)	Final demand for government consumption
GDTOT	Aggregate real government consumption
GENT	Transfer payments from government to enterprises
GNPVA	Nominal GNP or value added in market prices
GOVSAV	Government savings
GR	Total government revenue
HHSAV	Total household savings
HHT	Government transfer payments to households
ID(i)	Final demand for investment goods
INDTAX	Total indirect tax revenue

Continued--

Table 1--Definitions of indices, variables, and parameters--Continued

INVEST	Total investment
NETSUB	Total export subsidies
REMIT	Net remittances from abroad
RGNP	Real GNP
SAVINGS	Total savings
SSTAX	Social security tax revenue
TARIFF	Tariff revenue
TOTHHTAX	Household tax revenue
YFCTR(f)	Factor income
YH(hh)	Household income
YINST(ins)	Institutional income
	Parameters
ac(im)	CES function shift parameter
ad(i)	Production function shift parameter
alpha(i,f)	Share parameter in production function
at(ie)	CET function shift parameter
cles(i,hh)	Household expenditure shares
delta(im)	CES function share parameter
depr(i)	Depreciation rate
dstr(i)	Ratio of inventory investment to domestic output
econst(ied)	Export demand function shift parameter
esr	Enterprise saving rate
etr	Enterprise tax rate
fs(f)	Aggregate factor supply
gamma(ie)	CET function share parameter
gles(i)	Government expenditure shares
htax(hh)	Household income tax rate
imat(i,j)	Capital composition matrix
io(i,j)	Input-output coefficients
itax(i)	Indirect business tax rate
kish(i)	Shares of investment by sector of destination
mps(hh)	Household saving rate
pwm(im)	World price of imports
pwse(ied)	World price of export substitutes
rhoc(im)	CES function exponent
rhot(ie)	CET function exponent
rhsh(hh)	Household remittance share
sintyh(hh,ins)	Household distribution of institutional income
sstr	Social security tax rate
tm(im)	Tariff rate on imports
tmreal(im)	Real tariff rate
te(ie)	Export subsidy rates
tereal(ie)	Real export subsidy rate
thsh(hh)	Household share of government transfers
wfdist(i,f)	Factor market distortion parameters

Table 2--Price equations

(1)	im	PM(im)	= pwm(im)*(1 + tm(im))*EXR
(2)	ie	PE(ie)	= PWE(ie)*(1 + te(ie))*EXR
(3)	i	P(i)	= (PD(i)*XXD(i) + PM(i)*M(i))/X(i)
(4)	i	PX(i)	= (PD(i)*XXD(i) + PE(i)*E(i))/XD(i)
(5)	i	PVA(i)	= PX(i)*(1 - itax(i)) - SUM(j, io(j,i)*P(j))
(6)	i	PK(i)	= SUM(j, P(j)*imat(j,i))
(7)	1	PINDEX	= GNPVA/RGNP

Price Equations

Table 2 presents the model's price system. On the import side, the model incorporates the "small country" assumption: world prices (pwm) are exogenous. The domestic price of imports (PM) is simply the tariff-ridden world price times the exchange rate (EXR). On the export side, for some agricultural sectors, there is assumed to be a downward-sloping world demand curve for U.S. exports. For these sectors, the world price (PWE) is endogenous. The domestic price of exports, PE, includes any export subsidies.

Equations 3 and 4 describe the prices for the composite commodities X and XD. These equations reflect the homogeneity of the import aggregation and export transformation functions. The value of the composites must equal the value of their component parts, regardless of functional form. We discuss below the properties of the functions.[9]

Equation 5 defines the sectoral value-added or "net" price (PVA). It equals the output price minus indirect taxes and the cost of intermediate inputs (given fixed input-output coefficients).[10] The expression PVA·XD equals sectoral value added (at factor cost), which is paid to primary factors.

Equation 6 gives the price (PK) of a unit of capital installed in sector i. PK differs across sectors, reflecting the fact that capital used in different sectors is heterogeneous. The composition of capital goods used by a sector (by sector of origin) is given by the columns of the matrix imat. Because each column of imat sums to one, PK(i) is simply the weighted average of the costs of capital goods used in sector i.

Finally, equation 7 defines an aggregate price index (PINDEX), which is the GNP deflator. It equals nominal GNP (GNPVA) divided

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[9]In some models, it is convenient to use the dual price equations and drop the CES aggregation and CET transformation functions. For these functions, the two treatments are equivalent. When using flexible functional forms that are not self-dual, alternative treatments can matter.

[10]Note that indirect tax rates are computed on a base of PX. In other models, they are computed on a base of PD. See, for example, Devarajan, Lewis, and Robinson (1990).

by real GNP (RGNP). This is the numeraire price index that will be fixed, defining the absolute price level against which all relative prices will be measured. The GNP deflator is a convenient choice, but any other price index could be used. Other common choices in CGE models include a consumer or producer price index, the exchange rate, or the wage.

Quantity Equations

Table 3 gives the block of quantity equations, which effectively determine the supply side of the model. Equations 8 to 10 define the production technology and sectoral demand for factors. Equations 11 to 13 give the export transformation functions and the corresponding export supply functions, which depend on relative prices (PE/PD). Equation 14 gives the world demand functions for exports in sectors in which the United States is assumed to face a downward-sloping world demand curve (indexed by ied). Equations 15 to 17 give the import aggregation functions and the corresponding import demand functions, which depend on relative prices (PD/PM).

Equation 8 defines a Cobb-Douglas value-added production function with primary factors FDSC (including labor, capital, and land). The demand for intermediate inputs is given by equation 10, which assumes fixed input-output coefficients. The demand for primary factors, equation 9, reflects the first-order conditions for profit maximization using the value-added price, PVA. Given that the value-added price appears in equation 9, there is no need to define a separate variable for real value added. Consequently, XD appears in equations 8 and 9.

The model will solve for average factor prices, WF(f), that clear the factor markets. The model also allows for factor-market distortions. The parameters wfdist(i,f) are assumed fixed and

Table 3--Quantity equations

```
 (8)  i     XD(i)      = ad(i)*PROD(f, FDSC(i,f)**alpha(i,f))
 (9)  i,f   WF(f)*wfdist(i,f) = PVA(i)*alpha(i,f)*XD(i)/FDSC(i,f)
(10)  i     INT(i)     = SUM(j, io(i,j)*XD(j))
(11)  ie    XD(ie)     = at(ie)*(gamma(ie)*E(ie)**rhot(ie)
                         + (1-gamma(ie))*XXD(ie)**rhot(ie))**(1/rhot(ie))
(12)  ien   XD(ien)    = XXD(ien)
(13)  ie    E(ie)      = XXD(ie)*(PE(ie)/PD(ie)*(1 - gamma(ie))
                             /gamma(ie))**(1/(rhot(ie)-1))
(14)  ied   E(ied)     = econst(ied)*((PWE(ied)
                             /pwse(ied))**(-rhoe(ied)))
(15)  im    X(im)      = ac(im)*(delta(im)*M(im)**(-rhoc(im))
                         + (1-delta(im))*XXD(im)**(-rhoc(im)))**(-1/rhoc(im))
(16)  imn   X(imn)     = XXD(imn)
(17)  im    M(im)      = XXD(im)*((PD(im)/PM(im))*(delta(im)
                             /(1-delta(im))))**(1/(1+rhoc(im)))
```

measure the extent to which the marginal revenue product of a factor in a particular sector deviates from the average return for that factor across the economy. If there are no distortions in the factor markets, all the wfdist(i,f) parameters will equal one.

Total domestic production (XD) is supplied to domestic (XXD) or foreign (E) markets. The three goods are distinct, with separate prices, although they have the same sectoral classification. In effect, each sector is a two-product firm, producing goods for the export and domestic market. Equation 11 describes how sectoral production is transformed into goods for domestic markets and export markets.

The functional form of equation 11 is a constant elasticity of transformation (CET) function. Producers maximize revenue from sales subject to the CET transformation function. Export supply, equation 13, represents the first-order conditions and is a function of the relative export price to domestic price, the elasticity of transformation between the two uses, and the share parameters in the CET function.

Imported (M) and domestic goods (XXD) are also distinct, with separate sectoral prices. Consumers demand a composite good, which is a CES aggregate of imported and domestic goods with the same sectoral classification (equation 15). Import demand is given by equation 17, which is the first order condition for minimizing the cost of buying a given amount of composite good. The model thus allows cross-hauling (that is, simultaneous exports and imports) at the sectoral level.[11]

This treatment of exports and imports partially insulates the domestic price system from changes in world prices of sectoral substitutes. The specification of imperfect substitution and transformation is more realistic than the extreme dichotomy between perfect substitutes and nontraded goods commonly specified in analytic trade models. The particular functional forms used (CES and CET functions) embody strong assumptions about separability and the absence of income effects. The ratio of exports and imports to domestic sales at the sectoral level depends only on relative prices, with no income effects. These strong assumptions can be weakened without losing the fundamental assumption that domestic and foreign goods are imperfect substitutes. Hanson, Robinson, and Tokarick (1990), for example, specify import demand according to a flexible functional form, the Almost Ideal Demand System (AIDS). The AIDS system allows for a non-unitary income elasticity of demand for imports at the sectoral level.

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[11]The model also allows pure nontraded goods. In sectors with no exports or imports (indices ien and imn), the aggregation functions are not needed (equations 12 and 16).

Table 4--Income equations

(18)	f	YFCTR(f)	= SUM(i, WF(f)*wfdist(i,f)*FDSC(i,f))
(19)	1	YINST("labr")	= YFCTR("labor") - SSTAX
(20)	1	YINST("prop")	= YFCTR("land")
(21)	1	YINST("ent")	= YFCTR("capital") + GENT - ENTSAV - ENTTAX - DEPRECIA
(22)	hh	YH(hh)	= SUM(ins, sintyh(hh,ins)*YINST(ins)) + rhsh(hh)*REMIT*EXR + thsh(hh)*HHT
(23)	1	TARIFF	= SUM(im, tm(im)*pwm(im)*M(im))*EXR
(24)	1	INDTAX	= SUM(i, itax(i)*PX(i)*XD(i))
(25)	1	NETSUB	= SUM(ie, te(ie)*PWE(ie)*E(ie))*EXR
(26)	1	SSTAX	= sstr*YFCTR("labor")
(27)	1	ENTTAX	= etr*(YFCTR("capital") - DEPRECIA + GENT)
(28)	1	TOTHHTAX	= SUM(hh, htax(hh)*YH(hh))
(29)	1	DEPRECIA	= SUM(i, depr(i)*PK(i)*FDSC(i,"capital"))
(30)	1	ENTSAV	= esr*(YFCTR("capital") + GENT - ENTTAX - DEPRECIA)
(31)	1	HHSAV	= SUM(hh, mps(hh)*YH(hh)*(1 - htax(hh)))
(32)	1	GR	= TARIFF - NETSUB + INDTAX + TOTHHTAX + SSTAX + ENTTAX + FBOR*EXR
(33)	1	SAVINGS	= HHSAV + GOVSAV + DEPRECIA + FSAV*EXR + ENTSAV

Income Equations

Table 4 presents the equations that map the flow of income from value added to institutions and ultimately to households. Factor incomes (YFCTR) are defined in equation 18. They are mapped into institutional incomes (YINST) in equations 19 to 21, net of institutional taxes, savings, and government transfers. Using fixed allocation shares (sintyh), institutional income is distributed to households in equation 22. Households also receive income as remittances from abroad (generally negative for the United States) and transfers from the government. Taxes are determined in equations 23 to 28, and total government revenue is given in equation 32. Savings, including depreciation charges, are given in equations 29 to 31 and are summed in equation 33.

These income equations serve to fill out all the inter-institutional entries in the SAM. Many of these entries will be specific to the institutional structure of a particular country. For example, government revenue includes a term FBOR·EXR. In the U.S. accounts, this variable is net foreign transfers received by the U.S. Government (generally negative for the United States), minus net interest paid by the Government to foreigners on outstanding official debt. While they are listed as variables, many of these items will be set exogenously in the model or determined by simple share or multiplier parameters.

Table 5--Expenditure and equilibrium equations

```
Expenditure equations:

(34) i   P(i)*CD(i) = SUM(hh, cles(i,hh)*(1 - mps(hh))*YH(hh)
                      *(1 - htax(hh)))
(35) i   GD(i)      = gles(i)*GDTOT
(36) i   DST(i)     = dstr(i)*XD(i)
(37) 1   FXDINV     = INVEST - SUM(i, DST(i)*P(i))
(38) i   PK(i)*DK(i) = kish(i)*FXDINV
(39) i   ID(i)      = SUM(j, imat(i,j)*DK(j))
(40) 1   GNPVA      = SUM(i, PVA(i)*XD(i)) + INDTAX + TARIFF - NETSUB
(41) 1   RGNP       = SUM(i, CD(i) + DST(i) + ID(i) + GD(i))
                      + SUM(ie, (1 - tereal(ie))*E(ie))
                      - SUM(im, (1 - tmreal(im))*M(im))

Equilibrium equations:

(42) i   X(i)       = INT(i) + CD(i) + GD(i) + ID(i) + DST(i)
(43) f   SUM(i, FDSC(i,f))= fs(f)
(44) 1   GR         = SUM(i, P(i)*GD(i)) + GOVSAV + GENT + HHT
(45) 1   SUM(im, pwm(im)*M(im))= SUM(ie, PWE(ie)*E(ie)) + FSAV
                                 + REMIT + FBOR
(46) 1   SAVINGS    = INVEST
```

Expenditure and Equilibrium Equations

Table 5 gives equations that complete the circular flow of income and expenditure, determining the demands for goods by the various actors. Consumer expenditures, equation 34, are a function of prices and income according to a simplified version of the Linear Expenditure System (LES).[12] Government demand for final goods, equation 35, is defined in terms of fixed shares (gles parameter) of aggregate real government spending on goods and services (GDTOT). Equation 44 is the government balance equation, equating revenue and expenditure (including the deficit).

Equations 36 to 39 determine the demand for capital goods. The demands for new inventories (DST) are given by fixed coefficients times production (equation 36). Aggregate nominal fixed investment (FXDINV) equals total nominal investment (INVEST) minus the value of inventory accumulation (equation 37). Equation 38 determines fixed real investment by sector of destination (DK). The allocation of nominal fixed investment to sectors is given by fixed shares (kish), which sum to one over all sectors. Equation 39 translates investment by sector of destination into demand for capital goods by sector of origin, using the capital composition matrix (imat). Given the

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[12]In this case, all subsistence minima are set to zero. The LES reduces to fixed expenditure shares and a Cobb-Douglas utility function.

definition of PK(i), that SUM(i, kish(i)) = 1, and that SUM(i, imat(i,j)) = 1 for all j, then it will be true that:

FXDINV = SUM(i, PK(i)·DK(i)) = SUM(i, P(i)·ID(i)).

The basic CGE model is static, with the economywide capital stock specified as an exogenous variable. The model does generate savings, investment, and demands for capital goods. The capital goods, however, are assumed not to be installed during the period, and so simply represent a separate demand category. In a dynamic model, the assumption of heterogeneity of capital goods by sector of destination is very important, affecting the dynamic properties of different growth paths. In a static model, the assumption is less important, but does have some impact because different assumptions about the composition of investment by sector of destination will change the structure of demand. The specification of PK as sectorally differentiated reflects this assumption.[13]

Equations 40 and 41 define real and nominal GNP, which are used to define the GNP deflator in the price equation block. Defining GNP from the expenditure side, imports are valued at world prices times the exchange rate, net of tariffs. In defining value added, imports are purchased by producers at domestic market prices, which include tariffs. To make GNP calculated as the sum of value added (at market prices) consistent with GNP calculated from the expenditure side, tariffs must be added to total value added, which is done in equation 40.[14] In the definition of real GNP, real imports are defined net of "real" tariffs, given the real tariff rates tmreal(i).[15]

In principle, exports should be treated symmetrically with imports. In the national accounts, exports are valued at world prices times the exchange rate, so that export subsidies need to be netted out from the value added side, which is done in equation 40. Note that, unlike tariffs, export subsidies are distributed to producing sectors. In defining sectoral value added at market prices, they can be treated symmetrically with indirect taxes. Note also that PVA, defined in equation 5, includes export subsidies but excludes indirect taxes.[16]

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[13]Other U.S. models that have focused on tax analysis have all assumed that capital is not heterogeneous. See, for example, Ballard, Fullerton, Shoven, and Whalley (1985). In such a model, PK is a scalar and imat is a vector.

[14]In the U.S. National Income and Product Accounts (NIPA), tariffs are added to value added in the wholesale trade sector. The United Nations system of national accounts (SNA) keeps tariffs as a separate entry in the value added accounts.

[15]This treatment is standard in national accounting, with tmreal(i) defined as the tariff rates in the base year. Not all countries define "real" tariffs this way. Some deflate nominal tariffs by some deflator, say that for imports.

[16]The tereal(i) parameters are needed on the export side because it is customary to define real magnitudes in the base

Equations 42 to 46 define the system constraints that the model economy must satisfy. The model is a general equilibrium system, with all endogenous variables being jointly determined. In discussing how the economy satisfies these system constraints, however, it is useful to think in terms of equilibrium conditions and equilibrating variables. In a competitive market economy, market clearing is achieved by varying prices, and it is helpful to identify the price associated with each market.

Equation 42 states that the sectoral supply of composite commodities must equal demand and defines market-clearing equilibrium in the product markets. There is also an analogous sectoral market-clearing condition for domestically produced goods sold on the domestic market (XXD). However, from equation 17, the ratio of imports to domestic sales is assumed to be the same for all categories of demand. Thus, at the sectoral level, specifying a separate market-clearing condition for domestically produced goods sold on the domestic market amounts to multiplying through both sides of equation 42 by the ratio XXD(i)/X(i). A separate equation for domestically produced goods sold on the domestic market is not needed. When the market for composite goods clears, then so will the market for domestic goods.

Equation 43 defines equilibrium in the factor markets. The supplies of primary factors (fs) are assumed fixed exogenously and are given as parameters. Market clearing requires that total factor demand equal supply. The equilibrating variables are the average factor prices, WF(f). In the model as specified, all factors are freely mobile, including capital. The model must be seen as defining a longrun equilibrium in which sectoral capital stocks have time to adjust, equating rental rates across sectors.[17]

An alternative approach is to specify a shortrun model, with sectoral capital stocks fixed exogenously. Such a specification is easy to implement in the existing model structure. Fixing sectoral capital stocks amounts to making the FDSC(i,f) variables exogenous for the factor "capital." The corresponding factor market-clearing equation is redundant and can be dropped. With sectorally fixed capital stocks, however, it is not possible to assume that the rental rate will be the same across sectors. This condition can be relaxed in the model by simply specifying the wfdist(i,"capital") parameters as endogenous variables

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year such that PE(i) = 1, and we assume that PE is a subsidy-ridden price (see equation 2 in table 3). There is less consistency across countries in the treatment of export subsidies than in the treatment of tariffs. Many countries appear to value exports in their accounts at subsidy-ridden prices. Since export subsidies are forbidden under the GATT, national statistical agencies tend to assume they do not exist. In the United States, there were no export subsidies in 1982, the base year for the model.

[17]With the wfdist parameters, sectoral rental rates are not equated, but may differ from the average by the fixed ratios.

instead of parameters, adding n new equilibrating variables, and dropping the average factor return variable.[18] This treatment allows all sectoral rental rates to be determined endogenously, given the fixed sectoral capital stocks.

Macroeconomic Closure

The income and expenditure equations capture the three major macro balances: savings-investment, government deficit, and the balance of trade. Because the model is closed in that it satisfies Walras' Law, the three macro balances will satisfy the identity: private savings + government savings + foreign savings ≡ aggregate investment. The modeler must take care not to specify independent equations determining all of these components endogenously, because the resulting model will either not satisfy Walras' Law or be infeasible.

Equations 44 through 46 describe equilibrium conditions for the government deficit, balance of trade, and savings-investment balance. These can be seen as defining notions of macroeconomic equilibrium. Additional equations are required to define the equilibrating variables. Table 6 lists the conditions required, plus a few additional restrictions arising from the definition of traded sectors.

In this model, the government deficit is determined residually in equation 44. Equations 50 to 52 in table 6 fix government expenditure items, and GOVSAV is the equilibrating variable. The second macro equilibrium condition, equation 45, concerns the balance of trade equation. In the model as presented, equations 47 to 49 fix all the financing items in the trade balance equation: net foreign savings, remittances, and net official borrowing (FSAV, REMIT, and FBOR). The result is that the balance of trade in goods and services is set exogenously in the model.[19] The equilibrating variable is the nominal exchange rate, EXR. The equilibrating mechanism at work is that, given the numeraire in equation 53, changes in EXR change the relative prices of nontradables (PD) and tradables (PE and PM)--the real exchange rate.

The CGE model determines an equilibrium relationship between the exchange rate and the balance of trade. For example, an increase in EXR implies a real depreciation, with the sectoral prices of tradables (PE and PM) rising relative to PD. Given the export supply and import demand equations, a real depreciation should lead to higher exports and lower imports. An alternative closure

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[18]In the GAMS program, a variable can be effectively dropped by fixing its value to one.

[19]Note that since the model is based on the GNP accounts, trade in services includes factor services. Thus, the trade balance in this model is the current account balance. Many CGE models are based on the gross domestic product (GDP) accounts, with the balance of trade referring to goods and nonfactor services.

Table 6--Macro closure equations

Balance of trade:			
(47)	1	FSAV	= fsav
(48)	1	REMIT	= remit
(49)	1	FBOR	= fbor
Government balance:			
(50)	1	GDTOT	= gdtot
(51)	1	GENT	= gent
(52)	1	HHT	= hht
Numeraire price index:			
(53)	1	PINDEX	= pindex
Nontraded sectors and sectors with fixed export prices:			
(54)	imn	PM(imn)	= 0
(55)	imn	M(imn)	= 0
(56)	ien	PE(ien)	= 0
(57)	ien	E(ien)	= 0
(58)	iedn	PWE(iedn)	= pwe(iedn)

would be to fix the value of EXR (relative to the numeraire price index). The balance of trade would then be determined endogenously and one of the financing items (FSAV, REMIT, or FBOR) would have to be made into an endogenous variable.

The final macro closure condition (equation 46) requires that aggregate savings equals aggregate investment. Government revenue is determined by the various fixed tax parameters, and government saving (GOVSAV), as mentioned earlier, is determined residually in equation 44. Private savings are determined by various fixed institutional and household savings rates. Foreign saving is also fixed exogenously. The net effect is to specify a savings-driven model in which aggregate investment is determined by aggregate savings. This specification is called "neoclassical closure" in the CGE literature. Most of the U.S. applications of CGE models use some form of neoclassical closure. There are many alternative ways to achieve savings-investment equilibrium in the model, reflecting different theoretical perspectives on how the macro economy operates.[20]

[20]There is extensive literature on alternative macro closures of CGE models. See Robinson (1989a,b), Rattso (1982), and Dewatripont and Michel (1987). The seminal article is Sen (1963).

In a standard general equilibrium model, the system can only determine relative prices. The choice of numeraire (equation 53) should thus have no effect on the solution value of any real variables. As written, however, the real side of the CGE model is not homogeneous of degree zero in prices. That is, for example, doubling the numeraire price index (PINDEX) would not lead to a new solution with all real variables unchanged and all prices (including the exchange rate) doubled. The problem is that certain variables have been fixed exogenously in nominal terms: government transfers to enterprises and households, GENT and HHT. Unless these items are changed proportionately with any change in the numeraire price index, the real value of the transfers will change. Note that the foreign saving items (FSAV, REMIT, and FBOR) are not a problem, since they are fixed in foreign currency. Their value in domestic currency will change with the exchange rate, which will vary with the numeraire price index.

Counting Equations and Variables

The CGE model can be seen as a set of simultaneous nonlinear equations. Most such models are well-behaved neoclassical general equilibrium models that satisfy the conditions for existence proofs and will thus have at least one solution. In theory, models with many consumers (a typical formulation in applied CGE models) may have multiple equilibrium solutions. In practice, modelers have not found multiple equilibria, so the possibility is evidently more a problem for theorists than practitioners. See Kehoe (1985) and Mas Colell (1985) for discussions of the theoretical issues.

While generally neither necessary nor sufficient to ensure the existence of a solution, it is nonetheless reassuring to check that the number of endogenous variables equals the number of independent equations. Careful counting, set out below, indicates that the number of equations, including those that fix some variables exogenously, is one more than the number of endogenous variables.[21] The CGE model, however, satisfies Walras' Law and the equations defining the equilibrium conditions are not all independent. Any one of them can be dropped, thus equating the number of variables and equations. In the GAMS model, we drop equation 46, the savings-investment equilibrium condition. A test of the model solution is to compute aggregate savings and investment and check to see that they are equal, even though the equation is not explicitly included in the system that is solved.

Table 7 provides a count of equations and variables for the 10-sector U.S. model listed in Appendix 2. The number of variables and equations for each block is counted using the set indexes; i, f, ins, hh. For this model, the index values are: i = 10, f = 3,

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[21] Equations 54 to 58 are included to account for sectors in which there are no exports or imports, or for which there are no export demand functions.

Table 7--Count of equations and variables

Variables:

Price block:	$(8 \cdot i) + 2$	= 82
Quantity block:	$(6 \cdot i) + (f \cdot i) + 3$	= 93
Income block:	$(5 \cdot i) + f + ins + hh + 22$	= 81
Total:	$(19 \cdot i) + (f \cdot i) + f + ins + hh + 27$	= 256

Equations:

Price block:	$im + ie + (4 \cdot i) + 1$	= 60
Quantity block:	$(2 \cdot i) + (f \cdot i) + (2 \cdot ie) + ien + ied + (2 \cdot im) + imn$	= 92
Income block:	$f + hh + 14$	= 20
Expenditure block:	$(5 \cdot i) + 3$	= 53
Market clearing block:	$i + f + 3$	= 16
Macro closure:	7	= 7
Nontraded sectors:	$(2 \cdot imn) + (2 \cdot ien) + iedn$	= 9
Total:	$(12 \cdot i) + (f \cdot i) + (3 \cdot im) + (3 \cdot ie) + ied + (3 \cdot imn) + (3 \cdot ien) + iedn + (2 \cdot f) + hh + 28$	= 257

ins = 3, and hh = 3. The subsets of "i" for the model are: im = 9, ie = 10, ied = 3, imn = 1, ien = 0, and iedn = 7. There are 256 variables and 257 equations, one more equation than endogenous variables. However, as discussed above, the equations are not all independent and one of the equilibrium conditions can be dropped. Typically, the savings-investment or balance-of-trade equilibrium condition, equation 46 or 45, is dropped. In our model, we drop the savings-investment equation.[22]

Calibration of Model Parameters

In this section, we describe how base year data are used to calibrate model parameters. We calibrate parameters from a 1982 Social Accounting Matrix (SAM) data base plus additional estimated parameters such as values of various elasticities. The

[22]Adelman and Robinson (1978) and Dervis, de Melo, and Robinson (1982) typically dropped the excess-demand equation for the largest sector. Condon, Dahl, and Devarajan (1987) dropped the balance-of-trade equation. A symmetric approach is to define an additional endogenous variable equal to the difference between aggregate savings and investment and leave in the redundant equation. The additional variable must equal zero at the equilibrium solution.

base year model solution, given the calibrated parameters, should reproduce the base year SAM. Making sure the solution SAM is consistent with the input data SAM is a useful consistency check of the model equations, SAM data base, and calibrated parameters.

The data on the U.S. economy are organized into a SAM. Construction of the SAM is a major task in itself.[23] The development of the 1982 SAM for the United States is discussed in Hanson and Robinson (1989). In figure 2, we present an aggregated 1982 SAM which is consistent with the U.S. National Income and Product Accounts (NIPA).

The disaggregated SAM combines the input-output tables with the NIPA. The U.S. input-output tables are produced every 5 years. The last published table is for 1977. See U.S. Department of Commerce, Bureau of Economic Analysis (1984). The input-output table was updated to 1982 under a contract with the U.S. Forest Service.[24] With some further adjustments, this updated table provides the core data set for our model. In addition to the data in the NIPA and input-output tables, the data base for a CGE model includes quantity measures for factors of production, a capital composition matrix, and various elasticities.

Common practice in calibrating CGE models is to assume that the base year of the model is also the base year for price indices. Units are defined so that all prices equal one, and the sectoral flows in the SAM measure both real and nominal magnitudes. The initial goods market equilibrium between supply and demand is thus obtained at prices equal to one. Such choice of units simplifies the calibration procedure, although it is not required.[25]

In calibration, the model equations are solved in reverse. Given base-year values for the variables, the parameters are derived from the equations. Calibration is a mathematical, not a statistical, procedure. We describe the calibration procedure for some of the parameters, following the equation blocks above.

Production and Trade Aggregation Functions

For the quantity equation block, equations 8-17, we need to calibrate the parameters of the Cobb-Douglas production function, the CES aggregation function for imports and domestic goods, and

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[23]The data organization and reconciliation were facilitated by using a Fortran program call the "SAM Generator." The structure of the program is described in an appendix to Dervis, de Melo, and Robinson (1982).

[24]The work was done by a consulting firm called Engineering Economics Associates of Berkeley, California. When the official U.S. input-output tables for 1982 become available, we will update the 1982 SAM data base.

[25]In recent work with the USDA/ERS CGE model, we have rebased the model on a 1986 SAM with real magnitudes defined in terms of 1982 prices.

Figure 2--A SAM for the United States in 1982

	EXPENDITURES OR OUTLAYS									
Billions of dollars	1 Suppliers Commodity	2 Activity	3 Value added Labor	4 Capital	5 Enterprise	6 Institutional actors Household	7 Government	8 Capital	9 World	Row totals
RECEIPTS OR INCOME										
Suppliers										
1 Commodity		2,808.9				2,050.7	641.7	447.3		5,948.6
2 Activity	5,604.4						0.0		361.9	5,966.3
Value added										
3 Labor		1,907.0								1,907.0
4 Capital		1,000.2								1,000.2
Institutional actors										
5 Enterprise				1,000.2			47.5			1,047.8
6 Household			1,637.5		581.6		396.2		-1.2	2,614.0
7 Government	8.6	250.2	269.5		63.1	409.3			-26.1	974.6
8 Capital					403.1	154.0	-110.8		1.0	447.3
9 World	335.6									335.6
Column totals	5,948.6	5,966.3	1,907.0	1,000.2	1,047.8	2,614.0	974.6	447.3	335.6	

the CET transformation function for exports and domestic sales. In each, we choose elasticity values from econometric estimates available in the literature. Given these elasticities, the shift and share parameters can be calibrated from the base year data.

The Cobb-Douglas production function, equation 8, has four parameters: the three factor-share parameters and the shift parameter. The SAM data include production, XD(i), factor demand, FDSC(i,f), and factor income, FCTRY(i,f), all by sector. From factor demand by sector and factor income by sector the average factor price WF(f) and the factor price sectoral proportionality constants, wfdist(i,f), are calculated. In the next part of this section, we go into more detail on the factor price calculations.

The value-added price, PVA(i), also goes into the calculation of the production function parameters. This price depends on the producer price, the cost of intermediate goods, and the indirect business tax. Note that production and factor demand account for market distortions, because the distortions are captured in the wfdist parameters and in the value-added prices:

```
PVA(i) = PX(i)*(1 - itax(i)) - SUM(j, io(j,i)*P(j))
```

which include _ad valorem_ distorting taxes, itax(i). Any other _ad valorem_ tax or subsidy instruments can either be added to the model in the value-added price equation or included in the itax parameters.

The first order conditions for profit maximization, equation 9, define the factor demand equations. From equation 9, solve for the share parameters, alpha(i,f):

```
alpha(i,f) = wfdist(i,f)*WF(f)*FDSC(i,f)/(PVA(i)*XD(i))
```

Given that the data from the SAM add up, total factor payments must equal total value added in each sector. The effect is to assume constant returns to scale in production, so that the SUM(f, alpha(i,f)) will equal one in all sectors.

Once the factor shares are determined, the shift parameter of the Cobb-Douglas production function remains to be calibrated. Given the data on total output XD(i), factor employment FDSC(i,if), and the calibrated alpha(i,if), the ad(i) parameters are given by (from equation 8):

```
ad(i) = XD(i)/PROD(f, FDSC(i,f)**alpha(i,f))
```

Calibration of the CES and CET trade aggregation functions is very similar to the treatment of the production functions. The CES and CET functions are characterized by a non-unitary elasticity of substitution or transformation, share parameters (which sum to one), and a shift term. The various model equations do not suffice to identify all these: one parameter must be determined outside the model. Standard practice is to

use outside econometric estimates of the elasticity of substitution or transformation.[26]

For the CES function, the elasticity of substitution measures the degree to which imported and domestic versions of the "same" good can be substituted for each other. In the model, the rhoc(i) parameter equals (1/elasticity - 1). An analogous relationship holds for the rhot(i) parameter in the CET function.[27]

Given these elasticities, the import demand and export supply equations can be used to solve for the share parameters in the CES and CET function. From equation 17, the import demand equation, the delta parameters can be computed in two steps (with delta1 as an intermediate calculation):

```
delta1(im) = (PM(im)/PD(im))*(M(im)/XXD(im))**(1 + rhoc(im))
delta(im)  = delta1(im)/(1 + delta1(im))
```

Finally, the shift parameters are calculated from equation 15:

```
ac(im) = X(im)/[delta(im)*M(im)**(-rhoc(im))
          + (1 - delta(im))*XXD(im)**(-rhoc(im))]**(-1/rhoc(im))
```

The computation for the export supply function is similar.

Factor Price Sectoral Proportionality Constants

The parameters wfdist(i,f) relate sector-specific factor returns to the economywide average factor return, WF(f). The SAM includes data on factor payments by factor and sector. Coupled with data on the number of units of factors (workers, capital stock, and acres of land), both the sector-specific and economywide average factor returns can be calculated. For example, the sector-specific wage equals a sector's "wage bill" divided by the number of workers in the sector. The average wage is the economywide wage bill divided by the total number employed. Wfdist(i,"labor") for a sector is the ratio of the sector-specific to the average wage.

Gross capital returns by sector can be determined residually given data on value added, wages, and land rental. Given estimates of sectoral capital stocks, sectoral capital rental rates and the wfdist(i,"capital") parameters can be computed in the same manner as the parameters for labor.[28] An alternative approach used by Ballard, Fullerton, Shoven, and Whalley (1985) is to start with calculated wfdist parameters. They assume that the only reason capital rentals differ across sectors is

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[26]For the United States, substitution elasticities for imports have been estimated by Shiells, Stern, and Deardorff (1986), and more recently, by Reinert and Roland-Holst (1990).

[27]In the GAMS program, the parameters are read in as elasticities and the rhoc and rhot parameters are computed.

[28]We use capital-stock data from the U.S. Department of Commerce, Bureau of Economic Analysis (1987).

variation in tax rates. Given data on sectoral taxes, they estimate the wfdist parameter for capital in each sector. Assuming that after-tax rental rates must be equal across sectors, they then use an estimate of the economywide rental rate to compute sectoral capital stocks.

The wfdist(i,f) parameters reflect: (1) distortions in the factor markets such as impediments to factor mobility among sectors or differential tax rates, and/or (2) aggregation errors in the definition of factors. Examples of the second effect might be variations in capital vintages across sectors that are not captured in capital stock data or variations in the occupation, skill, or education composition of the labor force across sectors. The general equilibrium model assumes that the return to a given factor would be equal across sectors if the factors were indeed homogeneous and there were no rigidities or distortions.

The fact that there are rigidities and distortions is reflected in that the measured wfdist(i,f) parameters differ from one. By assuming these parameters to be constant across experiments, the modeler assumes that the structural characteristics responsible for the differentials are invariant to the question at hand. That is, all policy experiments must be seen as comparing second-best situations, given existing factor-market distortions. Indeed, the existence of such distortions is a strong argument for using CGE models, since welfare comparisons in second-best situations are usually theoretically ambiguous, with results depending on parameter values. Of course, it is possible to do experiments in which the wfdist parameters are changed, which is the approach taken in much of the public finance literature using CGE models.[29]

Tax and Saving Rates in the Income Equations

The parameters in the income equations include the institutional tax and saving rates as well as household tax and saving rates. The SAM data provide the values of total institutional and household income and the amounts saved and paid in taxes. The average tax and saving rates are simply calculated as the ratios of taxes or savings to the income base.

The institutional structure of the model depends on the household aggregation. For the types of households in the basic model, we distinguish institutions by their functional source of income. Institutional income is factor income net of institutional taxes and savings, and includes government transfers. The net income of the labor institution is labor income net of social security taxes.

The net income of the enterprise institution is the capital income of producers, net of the profit tax on enterprise income, retained earnings which goes to the capital account, and

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[29]For a survey of tax models, see Shoven and Whalley (1984).

depreciation which also goes to the capital account. Note that depreciation equals the depreciation rate depr(i) times the value of productive capital valued at replacement cost, an economic rather than a tax definition. The enterprise institution also receives business transfer payments from the government. The property institution receives the factor income for land.

Net institutional income is apportioned to households using fixed share parameters, sintyh(hh,ins), which represent shares of each type of institutional income received by the different household categories. For these parameters, the sum over households equals one for all institutions. The USDA/ERS CGE model can distinguish households in either of two ways: (1) according to income class (such as lower 40th percentile, mid-40th percentile, and upper 20th percentile); or (2) according to function or income source, such as workers, capitalists (or rentiers), and transfer recipients.[30] The model presented in Appendix 2 follows the functional household definition. For example, if only worker households earn the economy's labor income, the share to worker households is one, that is sintyh(worker,labor) = 1; while for nonworker households it is zero. All distributed profits and property income go to rentier households.

Household income is taxed, saved, or spent on consumer goods and services. The income received by households includes remittances from abroad, transfers from the government, and factor income. Household income tax payments are computed as an average tax rate times gross income, which includes transfer income and remittances from abroad (or net of remittances sent out of the country). The average tax rate, htax(hh), for each household type is calibrated from the income flows and taxes paid in the base year. Household average savings rates, mps(hh), are determined as the ratio of household savings to income net of taxes. Household remittances from abroad, REMIT, are exogenous variables denominated in foreign currency. Consequently, they are multiplied by the exchange rate to determine domestic income flows. Household remittance shares, rhsh(hh), are computed from base-year data.

Sectoral Composition of Expenditures

There are a number of parameters that determine the sectoral composition of various categories of demand. These categories include: (1) demand for intermediate inputs, io(i,j); (2) composition of capital goods, imat(i,j); (3) household average expenditure shares, cles(i,hh); (4) investment allocation by sector of destination, kish(i); and (5) government demand shares, gles(i). All these parameters are computed from base-year data.

Intermediate goods are demanded in fixed proportions, using input-output coefficients io(i,j) defined in real terms (that is,

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[30]Adelman and Robinson (1988) and Robinson, Kilkenny, and Adelman (1989) categorize households by income class. Hanson, Robinson, and Tokarick (1990) categorize by income source.

units of input per unit output). Note that intermediate demand is for the composite good. The elements of the capital composition matrix, imat(i,j), are also defined in real terms as units of composite good i required per unit of capital in sector j.[31] While these coefficients are fixed, the import shares are not because they are a function of relative prices (given the sectoral import aggregation functions).

The demand by household hh for good i depends on the cles(i,hh) parameters, which represent expenditure shares--the fraction of household hh's total nominal expenditure that is spent on good i. The different expenditure shares across household type are estimated from data on expenditure shares by income class. The government sectoral expenditure shares, gles(i), are defined in real terms since total government expenditure (GDTOT) is defined as a real magnitude. These shares are taken from the input-output table. Finally, the allocation of total nominal investment by sector of destination, the kish(i) parameters, are based on data from U.S. Department of Commerce, Bureau of Economic Analysis (1987).

Implementing the CGE Model in GAMS

Table 8 presents an outline of a CGE model programmed in GAMS. For those familiar with GAMS, the outline uses terms describing a typical GAMS program. See the GAMS manual by Brooke, Kendrick, and Meeraus (1988). The model listing in Appendix 2 follows this outline.

A GAMS program typically starts with statements that define "sets" used in the model. In the CGE model, these sets define the various indices for subscripted variables and parameters. We distinguish sets for production sectors, factors of production, institutions, and households.

Second, we declare and define the various parameters in the model. In the CGE model, there are three kinds of parameters. First, the entire base-year SAM is read in. Second, parameters that are estimated outside the model, such as various elasticities, are read in. Third, based on the read-in data and parameters, the remaining parameters are computed, completing the calibration process.

Third, the endogenous variables in the model are declared and defined. The solution procedure also requires that all endogenous variables be given an initial value to start the algorithm. In programming models, if initial values are not specified, most algorithms try a guess of zero. For a CGE model, where the solution is expected to yield strictly positive prices and quantities, such a guess would often lead to singularities

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[31]The capital composition matrix is derived from the capital flows table published by the U.S. Department of Commerce, Bureau of Economic Analysis (1985).

Table 8--Structure of a GAMS CGE model

1) Sets
   a) specified sets
   b) subsets

2) Parameters
   a) parameter declaration
      i) exogenous parameters
      ii) calibrated parameters
   b) parameter assignment
      i) enter data
      ii) assign exogenous parameters
      iii) calibrate parameters

3) Variables
   a) variable declaration
   b) variable initialization

4) Display input Social Accounting Matrix (SAM)

5) Equations
   a) equation declaration
   b) equation assignment
      i) model equations
      ii) model closure and variable restrictions

6) Model definition and solve command

7) Calculate and display result tables

or, at best, nasty scaling problems. It is important to provide guesses as close as possible to the expected solution. We use the base-year SAM to initialize all endogenous variables.

Fourth, the base-year SAM from calibrated parameters is displayed. This SAM should replicate the initial data before the model is solved, and provides a check on the data input, parameter calibration, and initialization of endogenous variables. If the calibration procedure is done correctly, the solution of the CGE model in the base year should replicate the initial SAM (within acceptable rounding error). Printing the pre-solution and post-solution SAM's facilitates debugging the calibration process.

Fifth, the equations of the model are declared and defined. The GAMS program follows closely the presentation of equations above. Then, sixth, the model is defined and solved. The equations that are to be included in the CGE model are listed. Next, there is a SOLVE statement that calls a solution algorithm, such as NLP for nonlinear programming, to solve the model.

Finally, after the SOLVE statement is executed, GAMS has solution values for all endogenous variables. It remains only to print them. This is done in part seven. GAMS has standard defaults

for printing solution reports. We turn off the default solution printing and generate our own output tables.

After a base-year or "benchmark" solution is created, the CGE model will typically be used to run counterfactual, comparative static, experiments. A parameter or exogenous variable is changed and the model is solved again. Given the structure of the GAMS program, it is important to make such changes after the initialization of parameters, but before the model SOLVE statement. A common error is to change some input data in the parameter assignment part of the program. What happens in this case is that all the calibrated parameters are changed to be consistent with the changed input data, completely changing the model. The result is not a comparative statics experiment, but a comparison of two different models that may, depending on the nature of the changed parameters, have the same SAM. We have found it convenient to do experiments using the SAVE and RESTART commands in GAMS. In this procedure, the base solution is saved and a new experiment file is created that includes the model changes, solve statement, and display statements for tables of results. Experiment results are generated by using the RESTART option when running the experiment GAMS program.

Applications, Variations, and Extensions

In this section, we discuss how the USDA/ERS CGE model has been used. The model is very close to the Walrasian, neoclassical paradigm. In most applications, it is necessary to make changes in the institutional and behavioral assumptions in order to have the model better reflect the workings of an actual economy. We will discuss some changes that have been used in the USDA/ERS model to analyze policy issues relating to agriculture and international trade.[32]

Comparative Statics and Dynamics

The CGE model described here represents a single period equilibrium. None of the arguments in the various equations involve lagged variables or expected future variables, so the model is really timeless. It determines a flow equilibrium based on signals for the current period only. A given benchmark solution does, however, reflect initial conditions and past circumstances captured in the base-year data set.

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[32]We make no attempt to provide a general survey of applications of CGE models. See Robinson (1989b) for a survey of applications to developing countries, Robinson (1990) and Hertel (1990) for surveys of agriculture-focused models, de Melo (1988) for a survey of recent trade-focused CGE models, Shoven and Whalley (1984) for an earlier review of models on taxation and trade, and Powell and Lawson (1986) for a review of policy modeling with the Australian ORANI model.

The most common use of CGE models is to do comparative statics experiments. The interpretation of the results involves a very simple notion of time: "long enough" for all specified equilibrium conditions to be satisfied. Whether that period is short, medium, or long run depends on assumptions about elasticities and factor mobility in the model. For example, the basic model assumes all factors are mobile, a longrun assumption.

Since the first applications of CGE models to developing countries, the models have been made dynamic by solving for a sequence of time-recursive solutions. Time-dependent variables (such as the aggregate capital stock, labor force, and total factor productivity) are "updated" between periods. These dated variables are assumed exogenous within periods. Time-recursive dynamic paths are generated as a sequence of static CGE models linked by an intertemporal model that updates dated variables.[33]

We have used this approach with the USDA/ERS model. Adelman and Robinson (1988) analyzed the 1981 to 1985 period. Robinson, Kilkenny, and Adelman (1989) used forward projections from 1986 to 1991. Hanson, Robinson, and Tokarick (1990) project from 1988 to 1991 and 1995. In the last two applications, the CGE model is loosely linked to econometric macroeconomic projection models which provide estimates of real GNP growth, foreign prices, the government deficit, the balance of trade, and the aggregate price level. Robinson, Kilkenny, and Adelman used the "Trend Growth Model" (TGM), which is described in Monaco (1987). Hanson, Robinson, and Tokarick use results from a world econometric model developed in the ERS by Malley (1990). The macro models provide a logical framework for modeling intertemporal linkages and nicely complement the within-period CGE model.[34]

Adelman and Robinson (1978) describe this approach to dynamics as "lurching equilibrium" and it captures many elements of "adaptive" dynamic models and "temporary equilibrium" macro models.[35] This approach to dynamics has been criticized by Bell and Srinivasan (1984) who argue that the models are not forward looking and hence are not "truly" dynamic. There are a few examples of forward-looking dynamic CGE models, ranging from two-period to longrun multiperiod models, but they are quite stylized.[36] Bell and Srinivasan also note that dynamic equilibrium models can only be used to generate steady-state solutions, and that such solutions are usually not very

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[33]This is the technique first used by Adelman and Robinson (1978). It has later been used in applications to developing countries. See Dervis, de Melo, and Robinson (1982).

[34]This approach to linking CGE and macro models is described in Robinson and Tyson (1984) and has also been used in Australia. See Cooper, McLaren, and Powell (1985).

[35]See Day and Cigno (1978) for examples of adaptive dynamic models.

[36]See Dervis (1975), Goulder and Eichengreen (1989), Goulder and Summers (1989), Jorgenson and Wilcoxen (1989), and Pereira and Shoven (1988).

realistic. Since applied models build on existing theory, not advance it, future advances in applied dynamic models will require further theoretical developments. Parsell, Powell, and Wilcoxen (1989) discuss some recent developments in reconciling applied general equilibrium models with dynamic macroeconomics.

Factor Markets

In the basic model, all primary factors of production are perfectly mobile. Given the fixed total supplies of primary factors, economywide average factor prices adjust to maintain full employment equilibrium. An alternative widely used in models of developing countries is to assume the sectoral employment of a primary factor such as capital is fixed. The underlying story is that the model incorporates a shortrun adjustment period in which capital is assumed immobile.

Fixing factor employment by sector amounts to adding equations to the system, so an equal number of endogenous equilibrating variables must be included. With sectoral capital stocks fixed, one must assume that sectoral rental rates will vary. This specification is easily accommodated in the CGE model by redefining the wfdist(i,f) parameters as variables and fixing the average factor price variable to one. Kilkenny and Robinson (1988, 1990) use this specification to explore the effect of policy changes under different assumptions about factor mobility.

Another common factor market assumption is to assume that the wage is not flexible. With a fixed wage, the labor market is assumed to be rationed. The standard assumption is that producers hire as much labor as they wish at the fixed wage and that suppliers are rationed; that is, there is involuntary unemployment. This specification is easily accommodated in the CGE model by specifying the wage as an exogenous variable and aggregate labor supply as endogenous. This option is noted with comments in the GAMS listing in Appendix 2.

Modeling Agricultural Programs

The USDA/ERS model was developed to analyze the impact on the economy of proposed changes in agricultural policies. To date, most of the applications have concerned trade liberalization and have worked with a 10-sector version of the model.[37] The standard approach to modeling agricultural programs has been to measure their total cost and use an equivalent fixed ad valorem subsidy in the model.[38] In the CGE model, this approach would be implemented by creating a subsidy parameter that would enter the model as a negative indirect tax. Everywhere the parameter itax(i) appears, there would be an additional subsidy parameter.

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[37]See Robinson, Kilkenny, and Adelman (1989).

[38]These subsidy rates, called producer subsidy equivalents or PSE's, have been computed for a number of countries. The data are reported in U.S. Department of Agriculture, Economic Research Service (1988).

Kilkenny and Robinson (1988, 1990) argue that using *ad valorem* equivalents is not an adequate approach to modeling the complex mix of agricultural policies in the United States. They have extended the basic CGE model to include an explicit modeling of the different government programs affecting U.S. agriculture, including import rationing, export subsidies, deficiency payments, and government stocking. Their empirical results indicate that explicit modeling of the programs is especially important when estimating changes in the cost of government programs under different macro and policy scenarios, as well as for welfare analysis and analysis of the effect on linked sectors of policy changes.

The explicit modeling of agricultural programs is, of necessity, fairly stylized in the context of a 10-sector model with only 3 agricultural sectors. The basic model has recently been expanded to include 30 sectors in order to provide a better framework for such analysis.[39] This expanded model should provide a richer framework for analyzing trade liberalization scenarios and proposed policy changes being discussed in the context of the 1990 farm bill.

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[39]Kilkenny (1990) describes how agricultural programs are modeled in the new 30-sector model.

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Appendix 1: Model Summary

This appendix brings together all the model equations, including the list of variable and parameter definitions. Endogenous variables are in upper case and parameters are in lower case. To treat a variable as exogenous, we add the suffix ".FX" (which means "fixed"). The suffix ".L" means "level" and refers to the value of a variable. These suffixes follow the GAMS language. In GAMS, before the model is solved, the .L suffix denotes an initial guess. After solution, it denotes the solution value.

Indices are also in lower case, but are always given in parentheses. In some equations, the index is replaced by a specific entry, given in quotes. As noted earlier, the words SUM and PROD denote the summation and product operators over the index given after the left parenthesis (Σ and Π).

Indices

i, j	Sectors
im	Sectors with imports
imn	Sectors without imports: im + imn = i
ie	Sectors with exports
ien	Sectors without exports: ie + ien = i
ied	Sectors with world export demand functions
iedn	Sectors with fixed world export prices: ied + iedn = ie
f	Factors of production: "labor," "capital," and "land"
ins	Institutions: "labr," labor; "ent," enterprises; "prop," proprietors
hh	Household types

Parameters

ac(im)	CES function shift parameter
ad(i)	Production function shift parameter
alpha(i,f)	Share parameter in production function
at(ie)	CET function shift parameter
cles(i,hh)	Household expenditure shares
delta(im)	CES function share parameter
depr(i)	Depreciation rate
dstr(i)	Ratio of inventory investment to domestic output
econst(ied)	Export demand function shift parameter
esr	Enterprise saving rate
etr	Enterprise tax rate
fs(f)	Aggregate factor supply
gamma(ie)	CET function share parameter
gles(i)	Government expenditure shares
htax(hh)	Household income tax rate
imat(i,j)	Capital composition matrix
io(i,j)	Input-output coefficients
itax(i)	Indirect business tax rate
kish(i)	Shares of investment by sector of destination
mps(hh)	Household saving rate
pwm(im)	World price of imports
pwse(ied)	World price of export substitutes
rhoc(im)	CES function exponent

rhot(ie)	CET function exponent
rhsh(hh)	Household remittance share
sintyh(hh,ins)	Household distribution of institutional income
sstr	Social security tax rate
tm(im)	Tariff rate on imports
tmreal(im)	Real tariff rate
te(ie)	Export subsidy rates
tereal(ie)	Real export subsidy rate
thsh(hh)	Household share of government transfers
wfdist(i,f)	Factor market distortion parameters

Variables

Prices Block

EXR	Exchange rate
P(i)	Price of composite good
PD(i)	Domestic sales price
PE(i)	Domestic price of exports
PINDEX	GNP deflator
PK(i)	Price of a unit of capital in each sector
PM(i)	Domestic price of imports
PVA(i)	Value added price
PWE(i)	World price of exports
PX(i)	Output price

Production Block

E(i)	Exports
FDSC(i,f)	Factor demand
INT(i)	Intermediate input demand
M(i)	Imports
WF(f)	Average factor price
X(i)	Composite goods supply
XD(i)	Domestic output
XXD(i)	Domestic sales

Income and Expenditure Blocks

CD(i)	Final demand for private consumption
DEPRECIA	Total depreciation charges
DK(i)	Fixed Investment by sector of destination
DST(i)	Inventory investment by sector
ENTSAV	Enterprise savings
ENTTAX	Enterprise tax revenue
FBOR	Net foreign borrowing
FXDINV	Fixed capital investment
FSAV	Foreign savings
GD(i)	Final demand for government consumption
GDTOT	Aggregate real government consumption
GENT	Transfer payments from government to enterprises
GNPVA	Nominal GNP or value added in market prices
GOVSAV	Government savings
GR	Total government revenue
HHSAV	Total household savings
HHT	Government transfer payments to households

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ID(i)           Final demand for investment goods
INDTAX          Total indirect tax revenue
INVEST          Total investment
NETSUB          Total export subsidies
REMIT           Net remittances from abroad
RGNP            Real GNP
SAVINGS         Total savings
SSTAX           Social security tax revenue
TARIFF          Tariff revenue
TOTHHTAX        Household tax revenue
YFCTR(f)        Factor income
YH(hh)          Household income
YINST(ins)      Institutional income
```

Equations

<u>Prices</u>

```
 (1) im    PM(im)         = pwm(im)*(1 + tm(im))*EXR
 (2) ie    PE(ie)         = PWE(ie)*(1 + te(ie))*EXR
 (3)  i    P(i)           = (PD(i)*XXD(i) + PM(i)*M(i))/X(i)
 (4)  i    PX(i)          = (PD(i)*XXD(i) + PE(i)*E(i))/XD(i)
 (5)  i    PVA(i)         = PX(i)*(1 - itax(i)) - SUM(j,io(j,i)*P(j))
 (6)  i    PK(i)          = SUM(j, P(J)*imat(j,i))
 (7)  1    PINDEX         = GNPVA/RGNP
```

<u>Production</u>

```
 (8)  i    XD(i)          = ad(i)*PROD(f, FDSC(i,f)**alpha(i,f))
 (9) i,f   WF(f)*wfdist(i,f) = PVA(i)*alpha(i,f)*XD(i)/FDSC(i,f)
(10)  i    INT(i)         = SUM(j, io(i,j)*XD(j))
(11) ie    XD(ie)         = at(ie)*(gamma(ie)*E(ie)**rhot(ie)
                            + (1 - gamma(ie))*XXD(ie)**rhot(ie))**(1/rhot(ie))
(12) ien   XD(ien)        = XXD(ien)
(13) ie    E(ie)          = XXD(ie)*(PE(ie)/PD(ie)*(1 - gamma(ie))/
                             gamma(ie))**(1/(rhot(ie)-1))
(14) ied   E(ied)         = econst(ied)*((PWE(ied)/pwse(ied))**(-rhoe(ied)))
(15) im    X(im)          = ac(im)*(delta(im)*M(im)**(-rhoc(im)) +
                             (1-delta(im))*XXD(im)**(-rhoc(im)))**(-1/rhoc(im))
(16) imn   X(imn)         = XXD(imn)
(17) im    M(im)          = XXD(im)*((PD(im)/PM(im))*(delta(im)/
                             (1 - delta(im))))**(1/(1 + rhoc(im)))
```

<u>Income Generation</u>

```
(18)  f    YFCTR(f)       = SUM(i, WF(f)*wfdist(i,f)*FDSC(i,f))
(19)  1    YINST("labr")   = YFCTR("labor") - SSTAX
(20)  1    YINST("prop")   = YFCTR("land")
(21)  1    YINST("ent")    = YFCTR("capital") + GENT - ENTSAV - ENTTAX
                                - DEPRECIA
(22) hh    YH(hh)         = SUM(ins, sintyh(hh,ins)*YINST(ins))
                            + rhsh(hh)*REMIT*EXR + thsh(hh)*HHT
(23)  1    TARIFF         = SUM(im, tm(im)*pwm(im)*M(im))*EXR
(24)  1    INDTAX         = SUM(i, itax(i)*PX(i)*XD(i))
(25)  1    NETSUB         = SUM(ie, te(ie)*PWE(ie)*E(ie))*EXR
(26)  1    SSTAX          = sstr*YFCTR("labor")
```

```
(27)  1     ENTTAX       = etr*(YFCTR("capital") - DEPRECIA + GENT)
(28)  1     TOTHHTAX     = SUM(hh, htax(hh)*YH(hh))
(29)  1     DEPRECIA     = SUM(i, depr(i)*PK(i)*FDSC(i,"capital"))
(30)  1     ENTSAV       = ESR*(YFCTR("capital") + GENT - ENTTAX - DEPRECIA)
(31)  1     HHSAV        = SUM(hh, mps(hh)*YH(hh)*(1 - htax(hh)))
(32)  1     GR           = TARIFF - NETSUB + INDTAX + TOTHHTAX + SSTAX
                                 + ENTTAX + FBOR*EXR
(33)  1     SAVINGS      = HHSAV + GOVSAV + DEPRECIA + FSAV*EXR + ENTSAV
```

Expenditure

```
(34)  i     P(i)*CD(i)   = SUM(hh, cles(i,hh)*(1 - mps(hh))*YH(hh)
                                 *(1 - htax(hh)))
(35)  i     GD(i)        = gles(i)*GDTOT
(36)  i     DST(i)       = dstr(i)*XD(i)
(37)  1     FXDINV       = INVEST - SUM(i, DST(i)*P(i))
(38)  i     PK(i)*DK(i)  = kish(i)*FXDINV
(39)  i     ID(i)        = SUM(j, imat(i,j)*DK(j))
(40)  1     GNPVA        = SUM(i, PVA(i)*XD(i)) + INDTAX + TARIFF - NETSUB
(41)  1     RGNP         = SUM(i, CD(i) + DST(i) + ID(i) + GD(i))
                                 + SUM(ie, (1 - tereal(ie))*E(ie))
                           - SUM(im, (1 - tmreal(im))*M(im))
```

Equilibrium Conditions

```
(42)  i     X(i)         = INT(i) + CD(i) + GD(i) + ID(i) + DST(i)
(43)  f     SUM(i, FDSC(i,f)) = fs(f)
(44)  1     GR           = SUM(i, P(i)*GD(i)) + GOVSAV + GENT + HHT
(45)  1     SUM(im, pwm(im)*M(im)) = SUM(ie, PWE(ie)*E(ie))
                                   + FSAV + REMIT + FBOR
(46)  1     SAVINGS      = INVEST
```

Macro Closure: Balance of Trade

```
(47)  1     FSAV.FX      = fsav.l
(48)  1     REMIT.FX     = remit.l
(49)  1     FBOR.FX      = fbor.l
```

Macro Closure: Government Balance

```
(50)  1     GDTOT.FX     = gdtot.l
(51)  1     GENT.FX      = gent.l
(52)  1     HHT.FX       = hht.l
```

Numeraire Price Index

```
(53)  1     PINDEX.FX    = pindex.l
```

Nontraded Sectors and Fixed Export Prices

```
(54)  imn   PM.FX(imn)   = 0
(55)  imn   M.FX(imn)    = 0
(56)  ien   PE.FX(ien)   = 0
(57)  ien   E.FX(ien)    = 0
(58)  iedn  PWE.FX(iedn) = pwe.l(iedn)
```

Appendix 2: GAMS Listing of U.S. CGE Model

This appendix provides a listing of the output from a GAMS execution of the U.S. model for 1982. Some output tables have been omitted to save space.

In solving CGE models, the GAMS program uses software designed to solve nonlinear programming problems. The solver most commonly used is the MINOS program developed at Stanford University, described in Appendix D of Brooke, Kendrick, and Meeraus (1988). The CGE model is treated by MINOS as a special programming problem that happens to have a unique feasible basis. Since there is only one feasible solution that satisfies the constraint equations, it does not matter what the objective function is. In the model listed here, we specify real GNP as the maximand. A good test of whether the model is specified correctly is to solve the problem twice, first maximizing GNP and second minimizing GNP. If the CGE model is properly specified, it will have a unique solution and the two solutions should be the same.

Using a nonlinear programming algorithm to solve a "square" model (that is one with as many constraints as variables) seems a bit wasteful. The algorithm MINOS uses to find a feasible basis, however, appears to provide a very robust approach to solving systems of simultaneous nonlinear equations. In the GAMS implementation of MINOS, it is possible to change parameters determining how MINOS operates so as to greatly improve its performance as an equation solver. The new parameters are specified in a file called MINOS5.OPT which GAMS reads when it starts to solve the problem. The MINOS5.OPT file for solving CGE models is listed below:

```
BEGIN
START ASSIGNED NONLINEARS BASIC
END
```

The details of how to use the MINOS5.OPT file are described in Appendix D.2 of Brooke, Kendrick, and Meeraus (1988). While changing these parameters usually improves the performance of MINOS in solving CGE models, it may make things worse. If the algorithm fails, try again without using the MINOS5.OPT file.

In doing experiments with the GAMS CGE model, save the base solution and use it as a starting point for doing experiments. In GAMS, a solution can be saved and reused using the "SAVE" and "RESTART" options. See the GAMS manual for details. Specifying this option saves the base-year solution as the initial "guess" for another model. The GAMS programs for doing experiments may then be written in a few lines. One need only specify changes in parameters or exogenous variables and add a new SOLVE statement. Following the SOLVE statement, a list of display statements may be copied from the base-year GAMS program to output results. Given that the entire base solution is stored, one can easily generate "ratio to base" tables by renaming the new results tables and computing ratios to the old tables (which contain the saved original base solution).

```
$TITLE USDA/ERS GAMS U.S. CGE MODEL FOR 1982
$OFFSYMLIST OFFSYMXREF OFFUPPER

*#### U.S. CGE MODEL WITH 1982 DATA BASE, Billions of Dollars.
*USDA/ERS GNP Version, April 1990
*Programmed by: Sherman Robinson, Kenneth Hanson, and Maureen Kilkenny.
*
*The model is based on GNP data, and includes exports and imports of
*factor services.

*###################### SET DECLARATION ############################

 SETS

 I     SECTORS                 / lvstk      dairy and meat
                                 expcrp     grains and oilseeds
                                 othcrp     other agriculture
                                 agproc     agric processing
                                 aginp      agric inputs
                                 intmnf     interm manuf
                                 fdmnf      final demand manuf
                                 trdtrn     trade and transport
                                 service    services
                                 resta      real estate /

 F     FACTORS OF PRODUCTION   / labor      labor
                                 capital    capital
                                 land       agricultural land /

 INS   INSTITUTIONS            / labr       labor
                                 ent        enterprises
                                 prop       property /

 HH    HOUSEHOLD TYPE          / hhtrn      transfer recipients
                                 hhlab      wage earners
                                 hhcap      rentiers /

* The institution names and the factor names "capital" and "land"
* are referred to explicitly below.  If changed, they must also be
* changed where referenced.
* The printing of the GNP accounts assume that there is a sector
* labelled "service."

*## SUBSETS DEFINED BELOW: "DEFINE INDEXES"

 IAG(I)          AG SECTORS      / lvstk, expcrp, othcrp /
 IAGN(I)         NON AG SECTORS

 IE(I)           EXPORT SECTORS
 IED(I)          SECTORS WITH EXPORT DEMAND EQN
 IEDN(I)         SECTORS WITH NO EXPORT DEMAND EQN
 IEN(I)          NON EXPORT SECTORS

 IM(I)           IMPORT SECTORS
 IMN(I)          NON IMPORT SECTORS

 ALIAS(I,J) ;

*## for SAM
 SET ISAM  categories
                      /COMMDTY,ACTIVITY,VALUAD,INSTTNS,HOUSEHOLDS,
                       GOVT,KACCOUNT,WORLD,TOTAL/
     ISAM1(isam)      /TOTAL/
     ISAM2(isam) ;
 ALIAS(isam2,isam3);
 PARAMETER SAM(isam,isam) SOCIAL ACCOUNTING MATRIX ;
 isam2(isam) = NOT isam1(isam) ;

```

```
*######################## PARAMETER DECLARATION #####################

 PARAMETERS

*### READ IN PARAMETERS

*## READ IN FOR INITIALIZATION OF VARIABLES
 ENTTAX0      ENTERPRISE TAX REVENUE
 ENTSAV0      ENTERPRISE SAVINGS
 EXR0         EXCHANGE RATE
 E0(i)        EXPORTS
 FBOR0        NET FOREIGN BORROWING
 FSAV0        NET FOREIGN SAVINGS
 GDTOT0       TOTAL VOLUME OF GOVERNMENT CONSUMPTION
 GENT0        PAYMENTS FROM GOVERNMENT TO ENTERPRISES
 GOVSAV0      GOVERNMENT SAVINGS
 HHSAV0       HOUSEHOLD SAVINGS
 HHT0         HOUSEHOLD TRANSFERS
 INVEST0      TOTAL INVESTMENT
 M0(i)        IMPORTS
 MPS0(hh)     HOUSEHOLD MARGINAL PROPENSITY TO SAVE
 PD0(i)       DOMESTIC GOODS PRICE
 PE0(i)       DOMESTIC PRICE OF EXPORTS
 PINDEX0      GNP DEFLATOR
 PM0(i)       DOMESTIC PRICE OF IMPORTS
 REMIT0       NET REMITTANCES FROM ABROAD
 SSTAX0       SOCIAL SECURITY TAX REVENUE
 TOTHHTAX0    HOUSEHOLD TAX REVENUE
 XD0(i)       DOMESTIC OUTPUT, VOLUMNE

*# READ IN TABLE FOR INITIALIZATION OF VARIABLES (NEED NOT BE DECLARED)
* TABLE FCTRES1(i,f) FACTOR DEMAND BY SECTOR
* TABLE FCTRY(i,f)   FACTOR INCOME BY SECTOR

*## READ IN PARAMETERS AS RATES, SHARES, ELASTICITIES
 DEPR(i)      DEPRECIATION RATES
 DSTR(i)      RATIO OF INVENTORY INVESTMENT TO GROSS OUTPUT
 ESR          ENTERPRISE SAVINGS RATE
 ETR          ENTERPRISE TAX RATE
 GLES(i)      GOVERNMENT CONSUMPTION SHARES
 HTAX(hh)     HOUSEHOLD TAX RATE
 ITAX(i)      INDIRECT TAX RATES
 KISH(i)      SHARES OF INVESTMENT BY SECTOR OF DESTINATION
 RHSH(hh)     HOUSEHOLD REMITTANCE SHARE
 RHOC(i)      ARMINGTON FUNCTION EXPONENT
 RHOE(i)      EXPORT DEMAND PRICE ELASTICITY
 RHOT(i)      CET FUNCTION EXPONENT
 SSTR         SOCIAL SECURITY TAX RATE
 TE(i)        EXPORT SUBSIDY RATES
 TM(i)        TARIFF RATES ON IMPORTS
 THSH(hh)     HOUSEHOLD SHARES OF GOVERNMENT TRANSFERS

*# READ IN TABLE OF PARAMETERS (NEED NOT BE DECLARED)
* TABLE CLES(i,hh)      HOUSEHOLD CONSUMPTION SHARES
* TABLE IMAT(i,j)       CAPITAL COMPOSITION MATRIX
* TABLE IO(i,j)         INPUT-OUTPUT COEFFICIENTS
* TABLE SINTYH(hh,ins)  HOUSEHOLD DISTRIBUTION OF INSTITUTIONAL INCOME

*### COMPUTED PARAMETERS FROM READ IN DATA (CALIBRATION)

*## COMPUTED PARAMETERS FOR INITIALIZATION OF VARIABLES
 DEPRECIA0     TOTAL DEPRECIATION EXPENDITURE
 FD0(f)        FACTOR DEMAND, AGGREGATE
 FS0(f)        FACTOR SUPPLY, AGGREGATE
 INT0(i)       INTERMEDIATE INPUT DEMAND
 NETSUB0       EXPORT DUTY REVENUE
 P0(i)         PRICE OF COMPOSITE GOOD
 PK0(i)        CAPITAL GOODS PRICE BY SECTOR OF DESTINATION
```

```
 PVAO(i)        VALUE ADDED PRICE BY SECTOR
 PWM(i)         WORLD MARKET PRICE OF IMPORTS (IN DOLLARS)
 PWEO(i)        WORLD PRICE OF EXPORTS
 PWSE(i)        WORLD PRICE OF EXPORT SUBSTITUTES
 PXO(i)         AVERAGE OUTPUT PRICE
 VARO(i)        VALUE ADDED RATE BY SECTOR
 WFDIST(i,f)    FACTOR PRICE SECTORAL PROPORTIONALITY CONSTANTS
 WFO(f)         FACTOR PRICE, AGGREGATE AVERAGE
 XXDO(i)        DOMESTIC SALES, VOLUMNE
 XO(i)          COMPOSITE GOOD SUPPLY, VOLUMNE
 YFCTRO(f)      FACTOR INCOME SUMMED OVER SECTOR
 YFLANDO(i)     FACTOR INCOME FOR LAND AS FRACTION OF CAPITAL INCOME
 YFSECTO(i)     FACTOR INCOME BY SECTOR
 YHO(hh)        HOUSEHOLD INCOME
 YINSTO(ins)    INSTITUTIONAL INCOME

*## COMPUTED PARAMETERS AS RATES, SHARES
 AC(i)          ARMINGTON FUNCTION SHIFT PARAMETER
 AD(i)          PRODUCTION FUNCTION SHIFT PARAMETER
 ALPHA(i,f)     FACTOR SHARE PARAMETER-PRODUCTION FUNCTION
 AT(i)          CET FUNCTION SHIFT PARAMETER
 DELTA(i)       ARMINGTON FUNCTION SHARE PARAMETER
 ECONST(i)      EXPORT DEMAND CONSTANT
 GAMMA(i)       CET FUNCTION SHARE PARAMETER
 PWTS(i)        PRICE INDEX WEIGHTS
 QD(i)          DUMMY VARIABLE FOR COMPUTING AD(i)
 RMD(i)         RATIO OF IMPORTS TO DOMESTIC SALES
 SUMSH          SUM OF SHARE CORRECTION PARAMETER
 SUMHHSH(hh)    SUM OF SHARE FOR HH CLES
 SUMIMSH(i)     SUM OF SHARE FOR IMAT
 TEREAL(i)      REAL EXPORT SUBSIDY RATE IN 1982 DOLLARS
 TMREAL(i)      REAL TARIFF RATE IN 1982 DOLLARS
        ;

*## TABLES USED FOR LOADING VARIABLE RESULTS
* TABLE SCALRES(*)     AGGREGATE RESULTS
* TABLE SECTRES(*,i)   SECTORAL PRICE AND QUANTITY RESULTS
* TABLE FCTRES1(i,f)   FACTOR DEMAND RESULTS
* TABLE FCTRES2(*,f)   FACTOR WAGE, SUPPLY AND INCOME RESULTS
* TABLE INSRES(*,ins)  INSTITUTIONAL INCOME RESULTS
* TABLE HHRES(*,hh)    HOUSEHOLD SAVINGS AND INCOME RESULTS


*######################## PARAMETER ASSIGNMENT #####################


 TABLE IO(i,j) INPUT-OUTPUT COEFFICIENTS

                   LVSTK       EXPCRP      OTHCRP      AGPROC      AGINP

  LVSTK          0.168150    0.028372    0.008224    0.136023    0.000958
  EXPCRP         0.271862    0.063924    0.003564    0.042413    0.010264
  OTHCRP         0.001403    0.001924    0.034676    0.029118    0.000696
  AGPROC         0.027162    0.001427    0.003346    0.219018    0.016157
  AGINP          0.215859    0.194453    0.141894    0.008308    0.127179
  INTMNF         0.007833    0.023602    0.042830    0.096847    0.488054
  FDMNF          0.013962    0.014380    0.015201    0.037832    0.026911
  TRDTRN         0.064683    0.066275    0.057563    0.078776    0.086941
  SERVICE        0.061396    0.076441    0.063132    0.068066    0.086447
  RESTA          0.022761    0.101945    0.042404    0.003908    0.004418

       +           INTMNF      FDMNF       TRDTRN      SERVICE     RESTA

  LVSTK          0.000265    0.000059    0.000069    0.000575    0.000000
  EXPCRP         0.000124    0.000037    0.000086    0.000355    0.000005
  OTHCRP         0.001697    0.000165    0.000072    0.000630    0.000078
  AGPROC         0.005055    0.011437    0.001673    0.020583    0.000037
  AGINP          0.032723    0.012603    0.045185    0.020652    0.005944
  INTMNF         0.283883    0.167023    0.011284    0.069580    0.001440
```

```
     FDMNF          0.048351     0.233953     0.031024     0.043826     0.008954
     TRDTRN         0.069999     0.070436     0.074135     0.040961     0.004047
     SERVICE        0.106268     0.100089     0.156346     0.156056     0.091112
     RESTA          0.023195     0.009930     0.026575     0.022218     0.070271
         ;

   TABLE IMAT(i,j) CAPITAL COMPOSITION MATRIX

                      LVSTK        EXPCRP       OTHCRP       AGPROC       AGINP

     LVSTK          0.000000     0.000000     0.000000     0.000000     0.000000
     EXPCRP         0.000000     0.000000     0.000000     0.000000     0.000000
     OTHCRP         0.000000     0.000000     0.000000     0.000000     0.000000
     AGPROC         0.000024     0.000000     0.000000     0.000128     0.000048
     AGINP          0.107920     0.572183     0.572183     0.000449     0.045514
     INTMNF         0.021095     0.012547     0.012547     0.038457     0.054939
     FDMNF          0.358399     0.109671     0.109671     0.852829     0.746376
     TRDTRN         0.000000     0.000000     0.000000     0.000000     0.000000
     SERVICE        0.512562     0.305599     0.305599     0.108137     0.153123
     RESTA          0.000000     0.000000     0.000000     0.000000     0.000000

         +            INTMNF       FDMNF        TRDTRN       SERVICE      RESTA

     LVSTK          0.000000     0.000000     0.000000     0.000000     0.000000
     EXPCRP         0.000000     0.000000     0.000000     0.000000     0.000000
     OTHCRP         0.000000     0.000000     0.000000     0.000000     0.000000
     AGPROC         0.000039     0.000088     0.000326     0.003320     0.003957
     AGINP          0.001101     0.000340     0.000371     0.008710     0.011875
     INTMNF         0.043006     0.011048     0.007640     0.018766     0.000125
     FDMNF          0.626612     0.886306     0.867568     0.235520     0.055912
     TRDTRN         0.000000     0.000000     0.000000     0.000000     0.000000
     SERVICE        0.329243     0.102218     0.124095     0.708126     0.891418
     RESTA          0.000000     0.000000     0.000000     0.025558     0.036713
         ;


 * FACTORS OF PRODUCTION

 *  LABOR IN MILLIONS OF EMPLOYEES
 *  CAPITAL IN BILLIONS OF 1982 $
 *  LAND IN MILLIONS OF ACRES
  TABLE FCTRES1(i,f) FACTOR DEMAND BY SECTOR

                      LABOR        CAPITAL     LAND

     LVSTK            0.415354    79.844060     0.000000
     EXPCRP           0.389786    72.290527   342.600000
     OTHCRP           0.495860    27.070413    85.650000
     AGPROC           3.584813    90.828916     0.000000
     AGINP            0.887448    80.391908     0.000000
     INTMNF           5.635211   574.659325     0.000000
     FDMNF            9.907532   291.267850     0.000000
     TRDTRN          18.648095   516.104860     0.000000
     SERVICE         55.605901  3871.778753     0.000000
     RESTA            1.070999   639.835386     0.000000
         ;

 * NOTE, CROPLAND INCOME IS READ AS A FRACTION OF CAPITAL INCOME
  TABLE FCTRY(i,f) FACTOR INCOME BY SECTOR

                      LABOR        CAPITAL     LAND

     LVSTK            4.792637     5.014664     0.000000
     EXPCRP           3.323859    26.065318     0.630000
     OTHCRP           4.906739    10.292489     0.630000
     AGPROC          65.741305    32.884451     0.000000
     AGINP           20.248245    13.974888     0.000000
     INTMNF         153.872100   115.536383     0.000000
     FDMNF          263.093487    49.561461     0.000000
```

```
  TRDTRN      330.332692  107.022255    0.000000
  SERVICE    1048.780635  493.262171    0.000000
  RESTA        11.908460  146.610508    0.000000
      ;

*## HOUSEHOLD PARAMETERS

 TABLE CLES(i,hh) HOUSEHOLD CONSUMPTION SHARES

                  HHTRN       HHLAB       HHCAP

  LVSTK          0.003931    0.003217    0.002309
  EXPCRP         0.000326    0.000470    0.000494
  OTHCRP         0.006344    0.005539    0.004931
  AGPROC         0.119976    0.114408    0.097157
  AGINP          0.024630    0.028957    0.022995
  INTMNF         0.010660    0.011127    0.010686
  FDMNF          0.089590    0.108451    0.113151
  TRDTRN         0.190825    0.188008    0.188198
  SERVICE        0.516858    0.502351    0.518905
  RESTA          0.036861    0.037470    0.041175
      ;

* NOTE, MPS(HHCAP) AND HTAX(HHLAB) ARE RECOMPUTED BELOW FROM VALUE DATA
 TABLE HHPAR(*,hh) MISCELLANEOUS HOUSEHOLD PARAMETERS

                  HHTRN       HHLAB       HHCAP

  THSH           1.000000    0.000000    0.000000
  RHSH           0.000000    0.000000    1.000000
  HTAX           0.000000    0.125960    0.350000
  MPS            0.000000    0.061607    0.174295
      ;


*## INSTITUTIONAL PARAMETERS

 TABLE SINTYH(HH,INS) HOUSEHOLD DISTRIBUTION OF INCOME

                  LABR        ENT         PROP

  HHTRN          0.000000    0.000000    0.000000
  HHLAB          1.000000    0.000000    0.000000
  HHCAP          0.000000    1.000000    1.000000
      ;


*## PRODUCTION SECTOR PARAMETERS

 TABLE SECTRES(*,I)  SECTORAL QUANTITIES AND PRICES

                  LVSTK       EXPCRP      OTHCRP      AGPROC      AGINP

  XD           77.115329   71.772915   26.543600  391.145476  265.279751
  E             0.211590   17.906935    1.517508   18.226606   19.340732
  M             0.653649    0.116664    2.782416   26.562680   23.669242
  PX            1.000000    1.000000    1.000000    1.000000    1.000000
  PE            1.000000    1.000000    1.000000    1.000000    1.000000
  PM            1.000000    1.000000    1.000000    1.000000    1.000000
  P             1.000000    1.000000    1.000000    1.000000    1.000000
  PD            1.000000    1.000000    1.000000    1.000000    1.000000
  PK            1.000000    1.000000    1.000000    1.000000    1.000000

       +          INTMNF      FDMNF       TRDTRN      SERVICE     RESTA

  XD          691.752575  817.593692  785.067268 2609.047268  230.939170
  E            46.868929  108.003057   37.123239  107.252244    5.449350
  M            89.196218  151.445719    1.845284   47.928267    0.000000
  PX            1.000000    1.000000    1.000000    1.000000    1.000000
```

```
 PE            1.000000    1.000000    1.000000    1.000000    1.000000
 PM            1.000000    1.000000    1.000000    1.000000    1.000000
 P             1.000000    1.000000    1.000000    1.000000    1.000000
 PD            1.000000    1.000000    1.000000    1.000000    1.000000
 PK            1.000000    1.000000    1.000000    1.000000    1.000000
     ;

* NOTE, TAXES ARE MAGNITUDES AND RATES ARE COMPUTED
 TABLE TAXR(*,I)  SECTORAL TAXES

                  LVSTK      EXPCRP      OTHCRP      AGPROC       AGINP

 ITAX          1.368870    1.276232    0.386298   10.774114    6.092757
 TE            0.000000    0.000000    0.000000    0.000000    0.000000
 TM            0.008711    0.003304    0.099223    2.746818    0.062378

      +          INTMNF       FDMNF      TRDTRN     SERVICE       RESTA

 ITAX         26.965991    9.696082   75.726551   87.474192   30.415138
 TE            0.000000    0.000000    0.000000    0.000000    0.000000
 TM            1.601493    4.028613    0.049061    0.000400    0.000000
     ;

 TABLE PARM(*,I)  MISCELLANEOUS PARAMETERS

                  LVSTK      EXPCRP      OTHCRP      AGPROC       AGINP

 DEPR          0.108183    0.108183    0.108183    0.095055    0.084635
 DSTR          0.000811   -0.006647   -0.004847   -0.006132   -0.008088
 GLES          0.000671    0.011649    0.001061    0.014240    0.019479
 KISH          0.012787    0.011577    0.004335    0.014547    0.012875

      +          INTMNF       FDMNF      TRDTRN     SERVICE       RESTA

 DEPR          0.111027    0.094561    0.093504    0.046913    0.042354
 DSTR         -0.006272   -0.010781   -0.003641   -0.001304    0.000000
 GLES          0.019867    0.152708    0.044819    0.725589    0.009918
 KISH          0.092033    0.046648    0.082656    0.620072    0.102470
      ;


 PARAMETER SCALRES(*) /
*#### MACRO TOTALS
 EXR      =    1.000000
 PINDEX   =    1.000000
 GDTOT    =  641.700000
 INVEST   =  447.300122
*#### TAX
 SSTAX     =  269.535402
 ENTTAX    =   63.079602
 TOTHHTAX  =  409.335747
*#### TRANSFER
 REMIT     =   -1.250000
 GENT      =   47.530000
 HHT       =  396.249995
 FBOR      =  -26.080000
*#### SAVE
 ENTSAV    =   20.030311
 HHSAV     =  153.907922
 GOVSAV    = -110.833017
 FSAV      =    1.029951
      /  ;

 TABLE ELASTICITY(*,I)  SECTORAL ELASTICITIES

        LVSTK     EXPCRP   OTHCRP   AGPROC    AGINP

 RHOC   4.0         4.0      4.0      2.0      0.75
 RHOT   0.5         4.0      2.0      2.0      2.0
```

```
 RHOE   3.0        3.0      3.0

  +    INTMNF     FDMNF   TRDTRN    SERVICE   RESTA

 RHOC   0.75       0.9      1.1      0.2      0.5
 RHOT   2.0        1.5      2.0      0.6      0.6
 RHOE
        ;

*################## END PARAMETER ASSIGNMENT ########################

*############ SPECIFY PARAMETERS FROM TABLE VALUES ###################

*## PARAMETERS FROM SCALRES(*)
 ENTSAVO    = SCALRES("ENTSAV");
 ENTTAXO    = SCALRES("ENTTAX");
 EXRO       = SCALRES("EXR") ;
 FBORO      = SCALRES("FBOR") ;
 FSAVO      = SCALRES("FSAV") ;
 GDTOTO     = SCALRES("GDTOT") ;
 GENTO      = SCALRES("GENT");
 GOVSAVO    = SCALRES("GOVSAV") ;
 HHSAVO     = SCALRES("HHSAV") ;
 HHTO       = SCALRES("HHT") ;
 INVESTO    = SCALRES("INVEST") ;
 PINDEXO    = SCALRES("PINDEX") ;
 REMITO     = SCALRES("REMIT") ;
 SSTAXO     = SCALRES("SSTAX");
 TOTHHTAXO  = SCALRES("TOTHHTAX") ;

*## OTHER TABLE VALUES OF PARAMETERS
 EO(i)      = SECTRES("E",i) ;
 ECONST(i)  = SECTRES("E",i) ;
 MO(i)      = SECTRES("M",i) ;
 PXO(i)     = SECTRES("PX",i) ;
 PEO(i)     = SECTRES("PE",i) ;
 PMO(i)     = SECTRES("PM",i) ;
 PO(i)      = SECTRES("P",i) ;
 PDO(i)     = SECTRES("PD",i) ;
 PKO(i)     = SECTRES("PK",i) ;
 XDO(i)     = SECTRES("XD",i);

 HTAX(hh)   = HHPAR("HTAX",hh) ;
 MPSO(hh)   = HHPAR("MPS",hh) ;
 RHSH(hh)   = HHPAR("RHSH",hh);
 THSH(hh)   = HHPAR("THSH",hh);

 ITAX(i)    = TAXR("ITAX",i)/(PXO(i)*XDO(i)) ;

 RHOC(i)    = (1/ELASTICITY("rhoc",i)) - 1 ;
 RHOE(i)    = ELASTICITY("rhoe",i);
 RHOT(i)    = (1/ELASTICITY("RHOT",i)) + 1;

 DEPR(i)    = PARM("DEPR",i) ;
 DSTR(i)    = PARM("DSTR",i) ;
 GLES(i)    = PARM("GLES",i);
 KISH(i)    = PARM("KISH",i) ;

*## NORMALIZE SHARE PARAMETERS TO CORRECT FOR ROUNDOFF ERROR
* These parameters (cles, imat, kish, and gles) can be read in as values
* and coverted to shares here.
 SUMHHSH(hh) = SUM(i, CLES(i,hh)) ;
 CLES(i,hh)  = CLES(i,hh)/SUMHHSH(hh) ;
 SUMIMSH(j)  = SUM(i, IMAT(i,j)) ;
 IMAT(i,j)   = IMAT(i,j)/SUMIMSH(j) ;
 SUMSH       = SUM(i, KISH(i)) ;
 KISH(i)     = KISH(i)/SUMSH ;
 SUMSH       = SUM(i, GLES(i)) ;
 GLES(i)     = GLES(i)/SUMSH ;
```

```
*#### DEFINE INDEXES BASED ON READ IN DATA
 IAGN(i)      = not IAG(i);
 IE(i)        = yes$EO(i);
 IED(i)       = yes$RHOE(i);
 IEDN(i)      = not IED(i);
 IEN(i)       = not IE(i);
 IM(i)        = yes$MO(i);
 IMN(i)       = not IM(i);

*## SPECIFY PARAMETERS WHICH DEPEND ON DEFINED INDEX IM AND IE
 TM(imn)      = 0.0 ;
 TM(im)       = TAXR("TM",im)/(PMO(im)*MO(im) - TAXR("TM",im)) ;
 TE(ien)      = 0.0 ;
 TE(ie)       = TAXR("TE",ie)/(PEO(ie)*EO(ie) - TAXR("TE",ie)) ;

*## COMPUTE FROM INITIAL DATA
 INTO(i)      = SUM(j, IO(i,j)*XDO(j));
 PVAO(i)      = PXO(i) - SUM(j, IO(j,i)*PO(j)) - ITAX(i) ;
 PWEO(i)      = PEO(i)/((1+TE(i))*EXRO);
 PWM(i)       = PMO(i)/((1+TM(i))*EXRO);
 VARO(i)      = PVAO(i) + ITAX(i) ;
 XXDO(i)      = XDO(i) - EO(i) ;

*## FOR 1982 TMREAL AND TEREAL ARE DERIVE FROM TM AND TE
*## FOR OTHER YEARS READ IN TMREAL AND TEREAL
 TMREAL(i)    = TM(i)*PWM(i)*EXRO ;
 TEREAL(i)    = TE(i)*PWEO(i)*EXRO ;
 NETSUBO      = SUM(i, TE(i)*EO(i)*PWEO(i))*EXRO ;


*################ CALIBRATION OF PARAMETERS FROM DATA ############

*## ADJUST FACTOR INCOME (CAPITAL) FOR FARM LAND
 YFLANDO(i)          = FCTRY(i,"land") ;
 FCTRY(i,"land")     = FCTRY(i,"capital")*YFLANDO(i) ;
 FCTRY(i,"capital") = FCTRY(i,"capital")*(1.0 - YFLANDO(i)) ;

*## FACTOR MARKET PARAMETERS
 FSO(f)        = SUM(i,FCTRES1(i,f)) ;
 YFCTRO(f)     = SUM(i, FCTRY(i,f)) ;
 YFSECTO(i)    = SUM(f, FCTRY(i,f)) ;
 WFO(f)        = YFCTRO(f)/FSO(f) ;
 WFDIST(i,f)$FCTRES1(i,f) = (FCTRY(i,f)/FCTRES1(i,f))/WFO(f) ;
 WFDIST(i,f)$(FCTRES1(i,f) EQ 0) = 0.0 ;

*## INSTITUTIONAL AND HOUSEHOLD INCOME, TAX RATE, AND SAVING RATE
 DEPRECIAO = SUM(i, DEPR(i)*PKO(i)*FCTRES1(i,"capital") ) ;
 SSTR = SSTAXO/YFCTRO("labor") ;
 ETR = ENTTAXO/(YFCTRO("capital") + GENTO - DEPRECIAO) ;
 ESR = ENTSAVO/(YFCTRO("capital") - ENTTAXO + GENTO - DEPRECIAO) ;
 YINSTO("labr") = (1.0 - SSTR)*YFCTRO("labor") ;
 YINSTO("ent")  = YFCTRO("capital") - ENTSAVO - ENTTAXO + GENTO
                  - DEPRECIAO ;
 YINSTO("prop") = YFCTRO("land") ;

*## NOTE, HOUSEHOLD INCOME IS FROM FACTORS (YHVAO) AND TRANSFERS
*## WHERE, YHVAO(hh) = SUM(ins, SINTYH(hh,ins)*YINSTO(ins))
 YHO(hh) = SUM(ins, SINTYH(hh,ins)*YINSTO(ins))
               + REMITO*RHSH(hh)*EXRO + HHTO*THSH(hh) ;

*## COMPUTE HTAX(hhlab) GIVEN OTHER HH TAX RATES AND TOTHHTAXO
*## WHERE, TOTHHTAXO = SUM(hh, HTAX(hh)*YHO(hh))
 HTAX("hhlab") = (TOTHHTAXO - HTAX("hhtrn")*YHO("hhtrn")
                 - HTAX("hhcap")*YHO("hhcap"))/YHO("hhlab");

*## COMPUTE MPSO(hhcap) GIVEN OTHER HH SAVINGS RATES AND HHSAVO
*## WHERE, HHSAVO = SUM(hh, MPSO(hh)*YHO(hh)*(1.0 - HTAX(hh)))
 MPSO("hhcap")=(HHSAVO - MPSO("hhtrn")*YHO("hhtrn")*(1.0-HTAX("hhtrn"))
```

```
                          - MPS0("hhlab")*YH0("hhlab")*(1.0-HTAX("hhlab")))
                /(YH0("hhcap")*(1.0 - HTAX("hhcap"))) ;


 DISPLAY WFDIST, WF0, FS0, YFSECT0, YFCTR0 ;
 DISPLAY YINST0,YH0,MPS0,HTAX,ETR,ESR,SSTR ;

*#### CALIBRATION OF SHIFT AND SHARE PARAMETERS ####

*## FOR IMPORTS-DOMESTIC COMPOSITE
*##  get delta from costmin, xo from absorption, ac from armington

 DELTA(i)     = (PM0(i)/PD0(i))*(M0(i)/XXD0(i))**(1+RHOC(i)) ;
 DELTA(i)     = DELTA(i)/(1.0+DELTA(i)) ;
 X0(i)        = (PD0(i)*XXD0(i) + (PM0(i)*M0(i))$im(i))/P0(i) ;
 RMD(i)       = M0(i)/XXD0(i) ;
 AC(i)$im(i)  = X0(i)/(DELTA(i)*M0(i)**(-RHOC(i))
                      +(1-DELTA(i))*XXD0(i)**(-RHOC(i)))**(-1/RHOC(i)) ;
 AC(i)$imn(i) = 1.0 ;
 display DELTA,AC,RMD ;

*## FOR EXPORTS
*## GET GAMMA FROM ESUPPLY
 GAMMA(ie)    = 1/(1 + PD0(ie)/PE0(ie)*(E0(ie)/XXD0(ie))**(RHOT(ie)-1));
*## GET AT FROM CET
 AT(ie)       = XD0(ie)/(GAMMA(ie)*E0(ie)**RHOT(ie) + (1-GAMMA(ie))*
                XXD0(ie)**RHOT(ie))**(1/RHOT(ie)) ;
 display GAMMA,AT ;

*## FOR FACTOR DEMAND
*## GET ALPHA FROM PROFIT MAX (ALPHA FOR EACH i SHOULD SUM TO 1)
 ALPHA(i,f)   = (WFDIST(i,f)*WF0(f)*FCTRES1(i,f))/YFSECT0(i) ;
 DISPLAY ALPHA ;

*## get AD from output and FD0 from profitmax
 QD(i)      = PROD(f, FCTRES1(i,f)**ALPHA(i,f)) ;
 AD(i)      = XD0(i)/QD(i);
 FD0(f)     = SUM(i,(XD0(i)*PVA0(i)*ALPHA(i,f)/(WFDIST(i,f)*
                WF0(f)))$WFDIST(i,f)) ;
 DISPLAY AD,QD,FD0 ;

*## SPECIFY WEIGHTS FOR PRODUCER PRICE INDEX
 PWTS(i)    = XD0(i)/SUM(j, XD0(j)) ;

*#### END OF CALIBRATION ####
 DISPLAY XD0, X0, XXD0 ;
 DISPLAY PVA0,PD0, PE0, PWE0, PM0, PWM, TM, PWTS ;

*######################################################################

 VARIABLES

*#################### VARIABLE DECLARATION #########################

*## PRICE BLOCK
   EXR       EXCHANGE RATE                                 ($ PER WORLD $)
   P(i)      PRICE OF COMPOSITE GOODS
   PD(i)     DOMESTIC PRICES
   PE(i)     DOMESTIC PRICE OF EXPORTS
   PINDEX    GNP DEFLATOR
   PK(i)     PRICE OF CAPITAL GOODS BY SECTOR OF DESTINATION
   PM(i)     DOMESTIC PRICE OF IMPORTS
   PVA(i)    VALUE ADDED PRICE
   PWE(i)    WORLD PRICE OF EXPORTS
   PX(i)     AVERAGE OUTPUT PRICE
*## PRODUCTION BLOCK
   E(i)      EXPORTS                                        (82 BILL $)
   M(i)      IMPORTS                                        (82 BILL $)
   X(i)      COMPOSITE GOODS SUPPLY                         (82 BILL $)
```

```
   XD(i)     DOMESTIC OUTPUT                                  (82 BILL $)
   XXD(i)    DOMESTIC SALES                                   (82 BILL $)
*## FACTOR BLOCK
   FS(f)     FACTOR SUPPLY
   FDSC(i,f) FACTOR DEMAND BY SECTOR
   WF(f)     AVERAGE FACTOR PRICE
   YFCTR(f)  FACTOR INCOME                                    (BILL $)
*## INCOME AND EXPENDITURE BLOCK
   CD(i)     FINAL DEMAND FOR PRIVATE CONSUMPTION             (82 BILL $)
   DEPRECIA  TOTAL DEPRECIATION EXPENDITURE                   (BILL $)
   DK(i)     VOLUME OF INVESTMENT BY SECTOR OF DESTINATION (82 BILL $)
   DST(i)    INVENTORY INVESTMENT BY SECTOR                   (82 BILL $)
   ENTSAV    ENTERPRISE SAVINGS                               (BILL $)
   ENTTAX    ENTERPRISE TAX REVENUE                           (BILL $)
   FBOR      NET FOREIGN BORROWING                            (BILL WORLD $)
   FSAV      NET FOREIGN SAVINGS                              (BILL WORLD $)
   FXDINV    FIXED CAPITAL INVESTMENT                         (BILL $)
   GD(i)     FINAL DEMAND FOR GOVERNMENT CONSUMPTION          (82 BILL $)
   GDTOT     TOTAL VOLUME OF GOVERNMENT CONSUMPTION           (82 BILL $)
   GENT      PAYMENTS FROM GOVT TO ENT                        (BILL $)
   GOVSAV    GOVERNMENT SAVINGS                               (BILL $)
   GR        GOVERNMENT REVENUE                               (BILL $)
   HHSAV     TOTAL HOUSEHOLD SAVINGS                          (BILL $)
   HHT       HOUSEHOLD TRANSFERS                              (BILL $)
   ID(i)     FINAL DEMAND FOR PRODUCTIVE INVESTMENT           (82 BILL $)
   INDTAX    INDIRECT TAX REVENUE                             (BILL $)
   INT(i)    INTERMEDIATES USES                               (82 BILL $)
   INVEST    TOTAL INVESTMENT                                 (BILL $)
   MPS(hh)   MARGINAL PROPENSITY TO SAVE BY HOUSEHOLD TYPE
   NETSUB    EXPORT DUTY REVENUE                              (BILL $)
   REMIT     NET REMITTANCES FROM ABROAD                      (BILL WORLD $)
   SAVINGS   TOTAL SAVINGS                                    (BILL $)
   SSTAX     SOCIAL SECURITY TAX REVENUE                      (BILL $)
   TARIFF    TARIFF REVENUE                                   (BILL $)
   TOTHHTAX  HOUSEHOLD TAX REVENUE                            (BILL $)
   YH(hh)    HOUSEHOLD INCOME                                 (BILL $)
   YINST(ins) INSTITUTIONAL INCOME                            (BILL $)
*## GNP CALCULATIONS
   RGNP      REAL GNP                                         (82 BILL $)
   GNPVA     VALUE ADDED IN MARKET PRICES GNP                 (BILL $)
        ;


*################## VARIABLE INITIALIZATION ########################

*## USE INITIAL VALUES OF VARIABLES (FROM PARAMETER SPECIFICATION)
 EXR.L     = EXR0 ;
 FBOR.L    = FBOR0 ;
 FSAV.L    = FSAV0 ;
 GDTOT.L   = GDTOT0 ;
 GENT.L    = GENT0 ;
 GOVSAV.L  = GOVSAV0 ;
 HHT.L     = HHT0 ;
 INVEST.L  = INVEST0 ;
 PINDEX.L  = PINDEX0 ;
 REMIT.L   = REMIT0 ;

 MPS.L(hh) = MPS0(hh) ;

 PD.L(i)   = PD0(i) ;
 P.L(i)    = P0(i) ;
 PX.L(i)   = PX0(i) ;
 PM.L(i)   = PM0(i) ;
 PE.L(i)   = PE0(i) ;
 XD.L(i)   = XD0(i) ;
 E.L(i)    = E0(i) ;
 M.L(i)    = M0(i) ;

 FDSC.L(i,f)  = FCTRES1(i,f) ;
```

```
 YFCTR.L(f)   = SUM(i, FCTRY(i,f)) ;

*## COMPUTE INITIAL VALUES FOR OTHER VARIABLES
*## OUTPUT AND PRICE
 XXD.L(i) = XD.L(i) - E.L(i) ;
 X.L(i)   = (PD.L(i)*XXD.L(i) + (PM.L(i)*M.L(i))$IM(i))/P.L(i) ;
 PK.L(i)  = SUM(J, P.L(j)*IMAT(j,i)) ;
 PWE.L(i) = PE.L(i)/((1.0 + TE(i))*EXR.L) ;
 PWSE(i)  = PWE.L(i) ;
 PVA.L(i) = PX.L(i) - SUM(J, IO(j,i)*P.L(j)) - ITAX(i) ;

*## VALUE ADDED AND THE FLOW OF FACTOR INCOME
 FS.L(f)          = SUM(i, FDSC.L(i,f)) ;
 WF.L(f)          = YFCTR.L(f)/FS.L(f) ;
 NETSUB.L         = SUM(ie, TE(ie)*E.L(ie)*PWE.L(ie))*EXR.L ;
 TARIFF.L         = SUM(im, PWM(im)*M.L(im)*TM(im))*EXR.L ;
 SSTAX.L          = SSTR*YFCTR.L("labor") ;
 INDTAX.L         = SUM(i, ITAX(i)*PX.L(i)*XD.L(i)) ;
 DEPRECIA.L       = SUM(i, DEPR(i)*PK.L(i)*FDSC.L(i,"capital")) ;
 ENTTAX.L         = ETR*(YFCTR.L("capital") + GENT.L - DEPRECIA.L) ;
 ENTSAV.L         = ESR*(YFCTR.L("capital") + GENT.L
                    - (ENTTAX.L + DEPRECIA.L)) ;
 YINST.L("labr") = YFCTR.L("labor") - SSTAX.L ;
 YINST.L("ent")  = YFCTR.L("capital") + GENT.L
                    - (ENTSAV.L + ENTTAX.L + DEPRECIA.L) ;
 YINST.L("prop") = YFCTR.L("land") ;
 YH.L(hh)         = SUM(ins, SINTYH(hh,ins)*YINST.L(ins))
                    + REMIT.L*RHSH(hh)*EXR.L + HHT.L*THSH(hh) ;
 TOTHHTAX.L       = SUM(hh, HTAX(hh)*YH.L(hh)) ;
 HHSAV.L          = SUM(hh, MPS.L(hh)*YH.L(hh)*(1.0 - HTAX(hh))) ;

*## FINAL DEMAND
 INT.L(i)  = SUM(j,IO(i,j)*XD.L(j)) ;
 CD.L(i)   = SUM(hh, CLES(i,hh)*(1.0 - MPS.L(hh))*YH.L(hh)
                 *(1.0 - HTAX(hh)))/P.L(i) ;
 GD.L(i)   = GLES(i)*GDTOT.L ;
 DST.L(i)  = DSTR(i)*XD.L(i) ;
 FXDINV.L  = INVEST.L - SUM(i, DST.L(i)*P.L(i)) ;
 DK.L(i)   = (KISH(i)*FXDINV.L)/PK.L(i) ;
 ID.L(i)   = SUM(j, IMAT(i,j)*DK.L(j)) ;
 GR.L      = TARIFF.L - NETSUB.L + INDTAX.L + TOTHHTAX.L + SSTAX.L
             + ENTTAX.L + FBOR.L*EXR.L ;
 SAVINGS.L = HHSAV.L + GOVSAV.L + DEPRECIA.L + FSAV.L*EXR.L + ENTSAV.L ;

*## GNP
 GNPVA.L   = SUM(i, PVA.L(i)*XD.L(i)) + INDTAX.L + TARIFF.L - NETSUB.L ;
 RGNP.L    = SUM(i, CD.L(i) + DST.L(i) + ID.L(i) + GD.L(i))
             + SUM(ie, (1.0 - TEREAL(ie)) * E.L(ie) )
             - SUM(im, (1.0 - TMREAL(im)) * M.L(im) ) ;
 PINDEX.L  = GNPVA.L/RGNP.L ;

*## ALTERNATIVELY, SET PINDEX TO THE PRODUCER PRICE INDEX
* PINDEX.L = SUM(i, pwts(i)*PX(i)) ;

 DISPLAY YFCTR.L,YINST.L,YH.L,GNPVA.L,RGNP.L,PINDEX.L ;
 DISPLAY INT.L,CD.L,GD.L,ID.L,DST.L,DK.L ;

*###################### END VARIABLE SPECIFICATION ##################

*#### TO CHECK FOR DATA CONSISTENCY, DISPLAY INITIAL SAM

*###################### SOCIAL ACCOUNTING MATRIX ######################

 SAM("COMMDTY","ACTIVITY")    = SUM(i,(P.L(i)*INT.L(i))) ;
 SAM("COMMDTY","HOUSEHOLDS")  = SUM(i,(P.L(i)*CD.L(i))) ;
 SAM("COMMDTY","KACCOUNT")    = SUM(i,(P.L(i)*(DST.L(i)+ID.L(i)))) ;
 SAM("COMMDTY","GOVT")        = SUM(i,(P.L(i)*GD.L(i))) ;
 SAM("ACTIVITY","WORLD")      = SUM(i,((EXR.L*PWE.L(i))*E.L(i))) ;
 SAM("ACTIVITY","COMMDTY")    = SUM(i,  (PX.L(i)*XD.L(i))
```

```
                                                    - (PE.L(i)*E.L(i)) ) ;
 SAM("ACTIVITY","GOVT")        = NETSUB.L ;
 SAM("VALUAD","ACTIVITY")      = SUM(f, YFCTR.L(f)) ;
 SAM("INSTTNS","VALUAD")       = SUM(f,YFCTR.L(f)) - SSTAX.L ;
 SAM("INSTTNS","GOVT")         = GENT.L ;
 SAM("HOUSEHOLDS","INSTTNS")= SUM((ins,hh),SINTYH(hh,ins)*YINST.L(ins));
 SAM("HOUSEHOLDS","GOVT")      = HHT.L ;
 SAM("KACCOUNT","INSTTNS")     = ENTSAV.L + DEPRECIA.L ;
 SAM("KACCOUNT","HOUSEHOLDS") = HHSAV.L ;
 SAM("KACCOUNT","GOVT")        = GOVSAV.L ;
 SAM("GOVT","COMMDTY")         = TARIFF.L ;
 SAM("GOVT","ACTIVITY")        = INDTAX.L ;
 SAM("GOVT","VALUAD")          = SSTAX.L ;
 SAM("GOVT","INSTTNS")         = ENTTAX.L ;
 SAM("GOVT","HOUSEHOLDS")      = TOTHHTAX.L ;
 SAM("WORLD","COMMDTY")        = SUM(i,((PWM(i)*EXR.L)*M.L(i))) ;
 SAM("WORLD","HOUSEHOLDS")     = - REMIT.L*EXR.L ;
 SAM("WORLD","GOVT")           = - FBOR.L*EXR.L ;
 SAM("WORLD","KACCOUNT")       = - FSAV.L*EXR.L ;
 SAM("TOTAL","COMMDTY")        = SUM(isam2,SAM(isam2,"COMMDTY")) ;
 SAM("TOTAL","ACTIVITY")       = SUM(isam2,SAM(isam2,"ACTIVITY")) ;
 SAM("TOTAL","VALUAD")         = SUM(isam2,SAM(isam2,"VALUAD")) ;
 SAM("TOTAL","INSTTNS")        = SUM(isam2,SAM(isam2,"INSTTNS")) ;
 SAM("TOTAL","HOUSEHOLDS")     = SUM(isam2,SAM(isam2,"HOUSEHOLDS")) ;
 SAM("TOTAL","KACCOUNT")       = SUM(isam2,SAM(isam2,"KACCOUNT")) ;
 SAM("TOTAL","GOVT")           = SUM(isam2,SAM(isam2,"GOVT")) ;
 SAM("TOTAL","WORLD")          = SUM(isam2,SAM(isam2,"WORLD")) ;
 SAM(isam3,"TOTAL")            = SUM(isam2,SAM(isam3,isam2)) ;

 OPTION DECIMALS=2 ;
 DISPLAY SAM ;
 OPTION DECIMALS=3 ;
*######################################################################

 EQUATIONS

*################### EQUATION DECLARATION ##########################

*## PRICE BLOCK
   PMDEF(i)          DEFINITION OF DOMESTIC IMPORT PRICES
   PEDEF(i)          DEFINITION OF DOMESTIC EXPORT PRICES
   ABSORPTION(i)     VALUE OF DOMESTIC SALES
   SALES(i)          VALUE OF DOMESTIC OUTPUT
   ACTP(i)           DEFINITION OF ACTIVITY PRICES
   PKDEF(i)          DEFINITION OF CAPITAL GOODS PRICE
   PINDEXDEF         DEFINITION OF GENERAL PRICE LEVEL
*## PRODUCTION BLOCK
   ACTIVITY(i)       PRODUCTION FUNCTION
   PROFITMAX(i,f)    FIRST ORDER CONDITIONS FOR PROFIT MAXIMUM
   INTEQ(i)          TOTAL INTERMEDIATE USES
   CET(i)            CET FUNCTION
   CET2(i)           DOMESTIC SALES FOR NONTRADED SECTORS
   ESUPPLY(i)        EXPORT SUPPLY
   EDEMAND(i)        EXPORT DEMAND FUNCTIONS
   ARMINGTON(i)      COMPOSITE GOOD AGGREGATION FUNCTION
   ARMINGTON2(i)     COMPOSITE GOOD AGG. FOR NONTRADED SECTORS
   COSTMIN(i)        F.O.C. FOR COST MINIMIZATION OF COMPOSITE GOOD
*## INCOME BLOCK
   YFCTREQ(f)        FACTOR INCOME
   LABORY            LABOR INCOME
   PROPY             PROPERTY INCOME
   ENTY              ENTERPRISE INCOME
   HHY(hh)           HOUSEHOLD INCOME
   TARIFFDEF         TARIFF REVENUE
   INDTAXDEF         INDIRECT TAXES ON DOMESTIC PRODUCTION
   NETSUBDEF         EXPORT SUBSIDIES
   TAXSS             SOCIAL SECURITY TAX
   ETAX              ENTERPRISE TAX
   HHTAXDEF          TOTAL HOUSEHOLD TAXES COLLECTED BY GOVT.
```

```
   DEPREQ           DEPRECIATION EXPENDITURE
   ESAVE            ENTERPRISE SAVINGS
   HHSAVEQ          HOUSEHOLD SAVINGS
   GREQ             GOVERNMENT REVENUE
   TOTSAV           TOTAL SAVINGS
*## EXPENDITURE BLOCK
   CDEQ(i)          PRIVATE CONSUMPTION BEHAVIOR
   GDEQI(i)         GOVT CONSUMPTION OF COMMODITIES
   GRUSE            GOVERNMENT SAVINGS
   DSTEQ(i)         INVENTORY INVESTMENT
   FIXEDINV         FIXED INVESTMENT NET OF INVENTORY
   PRODINV(i)       INVESTMENT BY SECTOR OF DESTINATION
   IEQ(i)           INVESTMENT BY SECTOR OF ORIGIN
*## MARKET CLEARING
   EQUIL(i)         GOODS MARKET EQUILIBRIUM
   FMEQUIL(f)       FACTOR MARKET EQUILIBRIUM
   CAEQ             CURRENT ACCOUNT BALANCE (BILL DOLLARS)
*  WALRAS           SAVINGS INVESTMENT EQUILIBRIUM

*## The WALRAS equation is redundant,
*## given that the model satisfies Walras' Law.
*## In this case, we drop the Savings-Investment balance equation.

*## GROSS NATIONAL PRODUCT
   GNPY             TOTAL VALUE ADDED INCLUDING INDTAX
   GNPR             REAL GNP
        ;


*######################## EQUATION ASSIGNMENT  #######################

*## PRICE BLOCK

 PMDEF(im)..     PM(im)  =E= PWM(im)*EXR*(1 + TM(im)) ;

 PEDEF(ie)..     PE(ie)  =E= PWE(ie)*(1 + TE(ie))*EXR ;

 ABSORPTION(i).. P(i)*X(i)   =E= PD(i)*XXD(i) + (PM(i)*M(i))$im(i) ;

 SALES(i)..      PX(i)*XD(i) =E= PD(i)*XXD(i) + (PE(i)*E(i))$ie(i) ;

 ACTP(i)..       PVA(i) =E= PX(i)*(1.0-ITAX(i)) - SUM(j,IO(j,i)*P(j)) ;

 PKDEF(i)..      PK(i)   =E= SUM(J, P(j)*IMAT(j,i)) ;

 PINDEXDEF..     PINDEX  =E= GNPVA/RGNP ;

*## PRODUCTION BLOCK

 ACTIVITY(i)..   XD(i)   =E= AD(i)*PROD(f$ALPHA(i,f),
                             FDSC(i,f)**ALPHA(i,f)) ;

 PROFITMAX(i,f)$WFDIST(i,f)..  WF(f)*WFDIST(i,f)*FDSC(i,f) =E=
                                          XD(i)*PVA(i)*ALPHA(i,f) ;

 INTEQ(i)..      INT(i)  =E= SUM(J, IO(i,j)*XD(j));

 CET(ie)..       XD(ie)  =E= AT(ie)*(GAMMA(ie)*E(ie)**RHOT(ie) +
                   (1-GAMMA(ie))*XXD(ie)**RHOT(ie))**(1/RHOT(ie)) ;

 CET2(ien)..     XD(ien) =E= XXD(ien) ;

 ESUPPLY(ie)..   E(ie)   =E= XXD(ie)*(PE(ie)/PD(ie)*(1 - GAMMA(ie))
                             /GAMMA(ie))**(1/(RHOT(ie)-1)) ;

 EDEMAND(ied)..  E(ied)  =E= ECONST(ied)*((PWE(ied)/PWSE(ied))
                                             **(-RHOE(ied))) ;

 ARMINGTON(im)..  X(im)  =E= AC(im)*(DELTA(im)*M(im)**(-RHOC(im)) +
```

```
                   (1 - DELTA(im))*XXD(im)**(-RHOC(im)))**(-1/RHOC(im)) ;

 ARMINGTON2(imn)..  X(imn) =E= XXD(imn) ;

 COSTMIN(im)..   M(im)/XXD(im) =E= (PD(im)/PM(im)*DELTA(im)/
                                  (1 - DELTA(im)))**(1/(1 + RHOC(im))) ;

*## INCOME BLOCK

 YFCTREQ(f)..    YFCTR(f) =E= SUM(i, WF(f)*WFDIST(i,f)*FDSC(i,f));

 LABORY..        YINST("labr") =E= YFCTR("labor") - SSTAX ;

 PROPY..         YINST("prop") =E= YFCTR("land") ;

 ENTY..          YINST("ent")  =E= YFCTR("capital") + GENT
                                   - (ENTSAV + ENTTAX + DEPRECIA) ;

 HHY(hh)..       YH(hh) =E= SUM(ins, SINTYH(hh,ins)*YINST(ins))
                            + REMIT*RHSH(hh)*EXR + HHT*THSH(hh) ;

 TARIFFDEF..     TARIFF =E= SUM(im, TM(im)*M(im)*PWM(im))*EXR ;

 INDTAXDEF..     INDTAX =E= SUM(i, ITAX(i)*PX(i)*XD(i)) ;

 NETSUBDEF..     NETSUB =E= SUM(ie, TE(ie)*E(ie)*PWE(ie))*EXR ;

 TAXSS..         SSTAX  =E= SSTR*YFCTR("labor") ;

 ETAX..          ENTTAX =E= ETR*(YFCTR("CAPITAL") - DEPRECIA + GENT) ;

 HHTAXDEF..      TOTHHTAX =E= SUM(hh, HTAX(hh)*YH(hh)) ;

 DEPREQ..        DEPRECIA =E= SUM(i, DEPR(i)*PK(i)*FDSC(I,"capital")) ;

 ESAVE..         ENTSAV =E= ESR*(YFCTR("CAPITAL")+GENT-ENTTAX-DEPRECIA);

 HHSAVEQ..       HHSAV  =E= SUM(hh, MPS(hh)*YH(hh)*(1 - HTAX(hh))) ;

 GREQ..          GR     =E= TARIFF - NETSUB + INDTAX +TOTHHTAX +
                                SSTAX + ENTTAX + FBOR*EXR ;

 TOTSAV..    SAVINGS =E= HHSAV + GOVSAV + DEPRECIA + FSAV*EXR + ENTSAV ;

*## EXPENDITURE BLOCK

 CDEQ(i)..       P(i)*CD(i) =E= SUM(hh, CLES(i,hh)*(1-MPS(hh))*YH(hh)
                                     *(1-HTAX(hh))) ;

 GDEQI(i)..      GD(i)  =E= GLES(i)*GDTOT ;

 GRUSE..         GR     =E= SUM(i, P(i)*GD(i)) + GOVSAV + GENT + HHT ;

 DSTEQ(i)..      DST(i) =E= DSTR(i)*XD(i) ;

 FIXEDINV..      FXDINV =E= INVEST - SUM(i, DST(i)*P(i)) ;

 PRODINV(i)..    PK(i)*DK(i) =E= KISH(i)*FXDINV ;

 IEQ(i)..        ID(i)  =E= SUM(J, IMAT(i,j)*DK(j));

*## MARKET CLEARING

 EQUIL(i)..      X(i)   =E= INT(i) + CD(i) + GD(i) + ID(i) + DST(i) ;

 FMEQUIL(f)..    SUM(i, FDSC(i,f)) =E= FS(f) ;

 CAEQ..          SUM(im, PWM(im)*M(im)) =E= SUM(ie, PWE(ie)*E(ie))
                                  +  FSAV + REMIT + FBOR ;
```

```

*WALRAS..        SAVINGS =E= INVEST ;

*## GROSS NATIONAL PRODUCT

 GNPY..      GNPVA =E= SUM(i,PVA(i)*XD(i)) + INDTAX + TARIFF - NETSUB ;

 GNPR..      RGNP =E= SUM(i,CD(i) + DST(i) + ID(i) + GD(i))
                    + SUM(ie,(1.0 - TEREAL(ie)) * E(ie) )
                    - SUM(im,(1.0 - TMREAL(im)) * M(im) ) ;

*#### ADDITIONAL RESTRICTIONS CORRESPONDING TO EQUATIONS
*# PMDEF, PEDEF, EDEMAND, ESUPPLY, COSTMIN, AND PROFITMAX
*# FOR NON-TRADED SECTORS AND SECTORS WITH FIXED WORLD EXPORT PRICES

 PM.FX(imn)   = PMO(imn) ;
 PE.FX(ien)   = PEO(ien) ;
 PWE.FX(iedn) = PWE.L(iedn) ;
 E.FX(ien)    = 0;
 M.FX(imn)    = 0;
 FDSC.FX(i,f)$(WFDIST(i,f) EQ 0) = 0 ;

*#### VARIABLE BOUNDS
*These are included to improve algorithm performance.  They are not
*necessary for model specification.
 P.LO(i)    = 0.0 ;  PD.LO(i)  = 0.0 ;  PM.LO(im) = 0.0 ;
 PK.LO(i)   = 0.0 ;  PX.LO(i)  = 0.0 ;  X.LO(i)   = 0.0 ;
 XD.LO(i)   = 0.0 ;  M.LO(im)  = 0.0 ;  XXD.LO(i) = 0.0 ;
 WF.LO(f)   = 0.0 ;  INT.LO(i) = 0.0 ;  E.LO(ie)  = 0.0 ;
 FDSC.LO(i,f)$(FDSC.L(i,f) NE 0) = 0.0 ;
 PVA.LO(i) = 0.0 ;

*############################ MODEL CLOSURE #############################

*## FOREIGN EXCHANGE MARKET CLOSURE
* In this version, the balance of trade (current account balance) is
* fixed exogenously and the exchange rate is the equilibrating variable.

*  EXR.FX     = EXR.L ;
   FSAV.FX    = FSAV.L ;
   REMIT.FX   = REMIT.L ;
   FBOR.FX    = FBOR.L ;

*## INVESTMENT-SAVINGS CLOSURE
* This version specifies neoclassical closure.  Aggregate investment is
* determined by aggregate savings; the model is savings driven.

   MPS.FX(hh) = MPS.L(hh) ;
*  INVEST.FX  = INVEST.L ;

*## EXOGENOUS GOVT EXPENDITURE
*## AND GOVT CLOSURE RULE
* Real government spending (GDTOT) is fixed exogenously.  The government
* deficit (GOVSAV) is determined residually.

   GDTOT.FX   = GDTOT.L ;
   GENT.FX    = GENT.L ;
   HHT.FX     = HHT.L ;
*  GOVSAV.FX  = GOVSAV.L ;

*## FACTOR MARKET CLOSURE
* In this version, all factors, including capital, are mobile.
* Commented equations allow a version with fixed wage for labor.
* The model then solves for aggregate employment.

   FS.FX(f)       = FS.L(f) ;
*  WF.FX("labor") = WF.L("labor") ;
*  FS.LO("labor") = -inf ;
*  FS.UP("labor") = +inf ;
```

```

*## NUMERAIRE PRICE INDEX
*In this case, the GNP deflator.

   PINDEX.FX = PINDEX.L ;


*########################### END OF MODEL ###########################

 OPTIONS ITERLIM=1000,LIMROW=0,LIMCOL=0,SOLPRINT=OFF;

 MODEL US82 /ALL/ ;

 SOLVE US82 MAXIMIZING RGNP USING NLP;


*#################### SOLUTION REPORTS AND OUTPUT ####################
*#### THREE REPORT AND OUTPUT BLOCKS
*## 1) TABLES OF RESULTS FOR VARIABLES IN MODEL
*## 2) TABLES OF RESULTS FOR DISPLAY
*## 3) TABLES OF RESULTS FOR RESTART SOLUTION RATIO TABLES
*## USE $ONTEXT AND $OFFTEXT TO TURN OFF REPORTS NOT WANTED.
*####################################################################

*#### 1) TABLES OF RESULTS FOR VARIABLES IN THE MODEL

*## MACRO AGGREGATE RESULTS
 SCALRES("EXR")      = EXR.L ;
 SCALRES("PINDEX")   = PINDEX.L ;
 SCALRES("RGNP")     = RGNP.L ;
 SCALRES("GNPVA")    = GNPVA.L ;

 SCALRES("INVEST")   = INVEST.L ;
 SCALRES("FXDINV")   = FXDINV.L ;
 SCALRES("GDTOT")    = GDTOT.L ;
 SCALRES("GR")       = GR.L ;

 SCALRES("SSTAX")    = SSTAX.L ;
 SCALRES("TARIFF")   = TARIFF.L ;
 SCALRES("INDTAX")   = INDTAX.L ;
 SCALRES("ENTTAX")   = ENTTAX.L ;
 SCALRES("TOTHHTAX") = TOTHHTAX.L ;
 SCALRES("NETSUB")   = NETSUB.L ;

 SCALRES("REMIT")    = REMIT.L ;
 SCALRES("GENT")     = GENT.L ;
 SCALRES("HHT")      = HHT.L ;
 SCALRES("FBOR")     = FBOR.L ;

 SCALRES("SAVINGS")  = SAVINGS.L ;
 SCALRES("ENTSAV")   = ENTSAV.L ;
 SCALRES("DEPRECIA") = DEPRECIA.L ;
 SCALRES("HHSAV")    = HHSAV.L ;
 SCALRES("GOVSAV")   = GOVSAV.L ;
 SCALRES("FSAV")     = FSAV.L ;


*## FACTOR OF PRODUCTION RESULTS
 FCTRES1(i,f)        = FDSC.L(i,f) ;

*## TABLE FCTRES2(*,f) MISCELLANEOUS FACTOR VARIABLE RESULTS ;
 SET IFVAR /WF, FS, YFCTR/ ;
 PARAMETER FCTRES2(ifvar,f) MISCELLANEOUS FACTOR VARIABLE RESULTS ;
 FCTRES2("WF",f)     = WF.L(f) ;
 FCTRES2("FS",f)     = FS.L(f) ;
 FCTRES2("YFCTR",f)  = YFCTR.L(f) ;

*## SECTORAL PRICE AND QUANTITY RESULTS
 SECTRES("P",i)   = P.L(i) ;
```

```
 SECTRES("PD",i)  = PD.L(i) ;
 SECTRES("PE",i)  = PE.L(i) ;
 SECTRES("PK",i)  = PK.L(i) ;
 SECTRES("PM",i)  = PM.L(i) ;
 SECTRES("PVA",i) = PVA.L(i) ;
 SECTRES("PWE",i) = PWE.L(i) ;
 SECTRES("PX",i)  = PX.L(i) ;

 SECTRES("X",i)   = X.L(i) ;
 SECTRES("XD",i)  = XD.L(i) ;
 SECTRES("XXD",i) = XXD.L(i) ;
 SECTRES("E",i)   = E.L(i) ;
 SECTRES("M",i)   = M.L(i) ;
 SECTRES("INT",i) = INT.L(i) ;
 SECTRES("CD",i)  = CD.L(i) ;
 SECTRES("GD",i)  = GD.L(i) ;
 SECTRES("ID",i)  = ID.L(i) ;
 SECTRES("DST",i) = DST.L(i) ;
 SECTRES("DK",i)  = DK.L(i) ;

*## INSTITUTIONAL RESULTS
*## TABLE INSRES(*,ins) INSTITUTIONAL INCOME RESULTS
 SET INSVAR /YINST/ ;
 PARAMETER INSRES(insvar,ins) INSTITUTIONAL INCOME RESULTS ;
 INSRES("YINST",ins) = YINST.L(ins) ;

*## HOUSEHOLD RESULTS
*## TABLE HHRES(*,hh) MISCELLANEOUS HOUSEHOLD RESULTS
 SET HHVAR /MPS, YH/ ;
 PARAMETER HHRES(hhvar,hh) MISCELLANEOUS HOUSEHOLD RESULTS ;
 HHRES("MPS",hh)      = MPS.L(hh) ;
 HHRES("YH",hh)       = YH.L(hh) ;

 option decimals = 6 ;
 DISPLAY SCALRES, FCTRES1, FCTRES2, SECTRES, INSRES, HHRES ;
 option decimals = 3 ;

*######################################################################

*#### 2) TABLES OF RESULTS FOR DISPLAY

*## DEFINE SETS FOR SOLUTION REPORT TABLES ####
* For GNP TABulations

 SET ignp  rows       /consmpt,Investment,Inventory,Government,
                        Exports,Imports,GNP /
     ignp1(ignp)      /gnp/
     ignp2(ignp)
     jgnp  columns    /nominal
                        real
                        nomshare
                        realshare
                        deflator / ;
 ignp2(ignp) = NOT ignp1(ignp) ;

 PARAMETER gnptab(ignp,jgnp)  GNP ACCOUNTS ;
 PARAMETER gnptab2(i,jgnp)    SECTORAL VALUE ADDED ;
 PARAMETER sumgnp(jgnp)       AGGREGATE GNP;
 PARAMETER gnpratio           GNP value added correction factor ;

* for ABSORB
 set rar  rows     / ag,non-ag,total /
     rac  columns  / GNP,C,I,G,E,M,NETE-M,T-G,ABSORB /
 PARAMETER ABSORB(rar,rac)    ABSORPTION TABLE (REAL) ;

* for FACTORS
 set rf / yf,yfcap,profit,rental,rdist,wdcap,
          yflabor,wdlabor,yfland,wdland,pint,intinp /
 PARAMETER FACTORS(i,rf)      FACTOR RETURNS DISTRIBUTIVE PARAMETERS ;
```

```

* for COEFFS (shift and share coefficients)
 set rc / ALPHAL,ALPHAC,ALPHAP,RMD,DELTA,AD /
 PARAMETER COEFFS(i,rc)       SHIFT,SHARE AND DISTRIBUTIVE PARAMETERS ;

*## DEFINE EXTRA PARAMETERS FOR SOLUTION REPORT TABLES ####

 PARAMETERS
            agtotfd     agricultural terms of trade
            agtotva     ag terms of trade value added
            agtote      ag terms of trade world export price
            agtotm      ag terms of trade world import price
            avgprofit   average profit rate
            avgwf       average factor price current weights
            bot         nominal balance of trade
            botr        real balance of trade
            colind      cost of living index
            esum        real exports
            exrind      real exchange rate index
            hold1       holds value for end calculation
            indhold     holds value for end calculation
            intinp(i)   intermediate input demand by sector i
            intinpn(i)  nominal intermediate input demand by sector i
            msum        real imports
            ncdtot      nominal cdtot
            nex         nominal exports
            nim         nominal imports
            ngdtot      nominal govt demand
            ngnp        nominal GNP
            pnagind     nonag price index
            pagind      ag price index
            pmind       domestic import price index
            peind       domestic export price index
            pweind      world export price index
            pwmind      world import price index
            psav        private savings
            pxind       producer price index
            pdind       domestic supply price index
            pind        composite good price index
            pint(i)     cost per unit of intermediate inputs
            profit(i)   profit rate
            rdist(i)    capital rental proportionality factor
            rental(i)   rental rate of capital
            shconsump   consumption share of nominal gnp
            shinvest    investment share of nominal gnp
            shex        export share of nominal gnp
            shim        import share of nominal gnp
            shgdtot     govt consumption share of nominal gnp
            shbot       balance of trade share of nominal gnp
            shfsav      foreign saving share of investment
            shgsav      government saving share of investment
            shpsav      private saving share of investment
            valadd(i)   value added at market price
            sectory(i)  value added at factor cost
            wtd(i)      base year wt domestic in total domestic sales
            wtm(i)      base year wt of imports in total trade
            wtx(i)      base year wt of exports in total trade
            yf(i,f)     factor income
                  ;

*#### SPECIFY EXTRA PARAMETERS FOR SOLUTION REPORT TABLES ####

*## AG TERMS OF TRADE ##
 pagind     = SUM(iag,px.l(iag)*xd.l(iag))/SUM(iag,xd.l(iag));
 pnagind    = SUM(iagn,px.l(iagn)*xd.l(iagn))/SUM(iagn,xd.l(iagn));
 agtotfd    = 100*pagind/pnagind;

 pagind     = SUM(iag,pva.l(iag)*xd.l(iag))/SUM(iag,xd.l(iag));
 pnagind    = SUM(iagn,pva.l(iagn)*xd.l(iagn))/SUM(iagn,xd.l(iagn));
```

```
 agtotva    = 100*pagind/pnagind;

 pagind     = SUM(iag,pwe.l(iag)*e.l(iag))/SUM(iag,e.l(iag));
 pnagind    = SUM(iagn,pwe.l(iagn)*e.l(iagn))/SUM(iagn,e.l(iagn));
 agtote     = 100*pagind/pnagind;
 pagind     = SUM(iag,pwm(iag)*m.l(iag))/SUM(iag,m.l(iag));
 pnagind    = SUM(iagn,pwm(iagn)*m.l(iagn))/SUM(iagn,m.l(iagn));
 agtotm     = 100*pagind/pnagind;

 DISPLAY agtotfd, agtotva, agtotm, agtote ;

*## MACRO BALANCES ##
 ncdtot     = SUM(i,cd.l(i)*p.l(i));
 ngdtot     = SUM(i,gd.l(i)*p.l(i));
 ngnp       = SUM(i,p.l(i)*(cd.l(i) + dst.l(i) + id.l(i) + gd.l(i))
                + pe.l(i)*e.l(i) - pwm(i)*exr.l*m.l(i));
 nex        = SUM(ie,e.l(ie)*exr.l*pwe.l(ie));
 nim        = SUM(im,m.l(im)*exr.l*pwm(im));
 bot        = nex-nim;
 botr       = SUM(i,e.l(i)) - SUM(i,m.l(i));
 esum       = SUM(i,e.l(i));
 msum       = SUM(i,m.l(i));
 psav       = invest.l - fsav.l - govsav.l;
 shbot      = 100*bot/gnpva.l;
 shconsump  = 100*ncdtot/gnpva.l;
 shex       = 100*nex/gnpva.l;
 shfsav     = 100*fsav.l/invest.l;
 shim       = 100*nim/gnpva.l;
 shinvest   = 100*invest.l/gnpva.l;
 shgdtot    = 100*ngdtot/gnpva.l;
 shgsav     = 100*govsav.l/invest.l;
 shpsav     = 100*psav/invest.l;

 DISPLAY bot,botr,nex,esum,nim,msum,shconsump,shinvest,
            shgdtot,shex,shim,shbot,shfsav,shgsav,shpsav;

*## INDEXES ##
* Note that cost of living index (COLIND) is the simple average over
* households.  CARD(hh) is the "cardinal" function which counts number
* of entries in the set.

 COLIND     = SUM(i,p.l(i)*(SUM(hh,cles(i,hh))))*100/CARD(hh);
 WTD(i)     = XXD0(i)/SUM(j,XXD0(j)) ;
 WTM(i)     = M0(i)/SUM(j,(M0(j)+E0(j))) ;
 WTX(i)     = E0(i)/SUM(j,(M0(j)+E0(j))) ;
 EXRIND     = SUM(i,WTD(i)*PD.L(i))
                  /SUM(i,(WTM(i)*PM.L(i))+(WTX(i)*PE.L(i)))*100 ;
 pdind      = SUM(i,xxd0(i)*pd.l(i))/SUM(j,xxd0(j))*100;
 peind      = SUM(i,e0(i)*pe.l(i))/SUM(j,e0(j))*100;
 pind       = SUM(i,x0(i)*p.l(i))/SUM(j,x0(j))*100;
 pmind      = SUM(i,m0(i)*pm.l(i))/SUM(j,m0(j))*100;
 pweind     = SUM(i,e0(i)*pwe.l(i))/SUM(i,e0(i))*100;
 pwmind     = SUM(i,m0(i)*pwm(i))/SUM(i,m0(i))*100;
 pxind      = SUM(i,pwts(i)*px.l(i))*100 ;

 DISPLAY colind,exrind,ngnp,pdind,pind,peind,pmind,pweind,pwmind,pxind;

*#### SPECIFY SOLUTION REPORT TABLES ####

*## GNP Tables ##

* Note treatment of tariffs.
* In U.S. NIPA, tariffs are included in the service sector.
* In the U.N. SNA, tariffs are treated separately.
* Treatment below follows U.S. NIPA practice.
* Note that real GNP from expenditure side provides the control total,
* and sectoral real value addeds are adjusted
* to match total using gnpratio.

```

```
gnptab("consmpt","nominal")     = SUM(i,p.l(i)*cd.l(i)) ;
gnptab("consmpt","real")        = SUM(i,cd.l(i));
gnptab("investment","nominal")  = SUM(i,p.l(i)*id.l(i));
gnptab("investment","real")     = SUM(i,id.l(i)) ;
gnptab("inventory","nominal")   = SUM(i,p.l(i)*dst.l(i)) ;
gnptab("inventory","real")      = SUM(i,dst.l(i)) ;
gnptab("government","nominal")  = SUM(i,p.l(i)*gd.l(i)) ;
gnptab("government","real")     = SUM(i,gd.l(i)) ;
gnptab("exports","nominal")     = SUM(i,pwe.l(i)*e.l(i))*exr.l ;
gnptab("exports","real")        = SUM(i,(1.0 - tereal(i))*e.l(i)) ;
gnptab("imports","nominal")     = -SUM(i,pwm(i)*m.l(i))*exr.l ;
gnptab("imports","real")        = -SUM(i,(1.0 - tmreal(i))*m.l(i)) ;
gnptab("gnp","nominal")    = SUM(ignp2,gnptab(ignp2,"nominal")) ;
gnptab("gnp","real")       = SUM(ignp2,gnptab(ignp2,"real")) ;
gnptab(ignp,"nomshare")    = 100.*gnptab(ignp,"nominal")
                                 /gnptab("gnp","nominal") ;
gnptab(ignp,"realshare")   = 100.*gnptab(ignp,"real")
                                              /gnptab("gnp","real") ;
gnptab(ignp,"deflator")    = 100.*gnptab(ignp,"nominal")
                                              /gnptab(ignp,"real") ;

gnptab2(i,"nominal")      = pva.l(i)*xd.l(i) + itax(i)*px.l(i)*xd.l(i)
                            - te(i)*pwe.l(i)*e.l(i)*exr.l ;
gnptab2("service","nominal") = gnptab2("service","nominal") + tariff.l;
gnptab2(i,"real")         = var0(i)*xd.l(i) ;
gnptab2("service","real") = gnptab2("service","real")
                            + SUM(i,tmreal(i)*m.l(i));
sumgnp("nominal")        = SUM(i,gnptab2(i,"nominal")) ;
sumgnp("real")           = SUM(i,gnptab2(i,"real")) ;
gnpratio                 = gnptab("gnp","real")/sumgnp("real") ;
gnptab2(i,"real")        = gnpratio*gnptab2(i,"real") ;
sumgnp("real")           = SUM(i,gnptab2(i,"real")) ;
gnptab2(i,"nomshare")    = 100*gnptab2(i,"nominal")/sumgnp("nominal") ;
gnptab2(i,"realshare")   = 100*gnptab2(i,"real")/sumgnp("real") ;
sumgnp("nomshare")       = SUM(i,gnptab2(i,"nomshare")) ;
sumgnp("realshare")      = SUM(i,gnptab2(i,"realshare")) ;
gnptab2(i,"deflator")    = 100.*gnptab2(i,"nominal")/gnptab2(i,"real");

DISPLAY  GNPTAB, GNPTAB2, SUMGNP, GNPRATIO ;

*## REPORT ABSORPTION ##
absorb("ag","c")          = SUM(iag,CD.L(iag)) ;
absorb("non-ag","c")      = SUM(iagn,CD.L(iagn)) ;
absorb("total","c")       = SUM(i,CD.l(i)) ;
absorb("ag","i")          = SUM(iag,ID.L(iag)) ;
absorb("non-ag","i")      = SUM(iagn,ID.L(iagn)) ;
absorb("total","i")       = SUM(i,ID.L(i)) ;
absorb("ag","g")          = SUM(iag,GD.L(iag)) ;
absorb("non-ag","g")      = SUM(iagn,GD.L(iagn)) ;
absorb("total","g")       = SUM(i,GD.L(i)) ;
absorb("ag","E")          = SUM(iag,E.L(iag)) ;
absorb("non-ag","E")      = SUM(iagn,E.L(iagn)) ;
absorb("total","E")       = SUM(i,E.L(i)) ;
absorb("ag","M")          = SUM(iag,M.L(iag)) ;
absorb("non-ag","M")      = SUM(iagn,M.L(iagn)) ;
absorb("total","M")       = SUM(i,M.L(i)) ;
absorb("ag","NETE-M")     = SUM(iag,E.L(iag))-SUM(iag,M.L(iag)) ;
absorb("non-ag","NETE-M") = SUM(iagn,E.L(iagn))-SUM(iagn,M.L(iagn)) ;
absorb("total","NETE-M")  = esum - msum ;
absorb("total","T-G")     = govsav.L ;
absorb("ag","GNP")        = SUM(iag,cd.l(iag)+dst.l(iag)+id.l(iag)
                               +gd.l(iag)+e.l(iag)-m.l(iag)) ;
absorb("non-ag","gnp")    = rgnp.l - absorb("ag","gnp") ;
absorb("total","gnp")     = rgnp.l ;
absorb("ag","absorb")     = SUM(iag,cd.l(iag)+id.l(iag)+gd.l(iag)) ;
absorb("non-ag","absorb") = SUM(iagn,cd.l(iagn)+id.l(iagn)+gd.l(iagn));
absorb("total","absorb")  = SUM(i,cd.l(i)+id.l(i)+gd.l(i)) ;

DISPLAY ABSORB ;
```

```
*### calculate and report selected parameters and coefficients #########
 INTINP(j)  = sum(i, IO(i,j)*XD.L(j)) ;
 INTINPN(j) = sum(i, P.L(i)*IO(i,j)*XD.L(j)) ;
 PINT(i)    = SUM(J, IO(J,i)*P.L(j)) ;
 YF(i,f)    = WFDIST(i,f)*WF.L(f)*FDSC.L(i,f) ;
 PROFIT(i)  = (WFDIST(i,"capital")*WF.L("capital")*FDSC.L(i,"capital"))
               /(FDSC.L(i,"capital")*PK.L(i)) ;
 AVGPROFIT  = SUM(I, WFDIST(i,"capital")*WF.L("capital")
              *FDSC.L(i,"capital"))/SUM(I, FDSC.L(i,"capital")*PK.L(i));
 AVGWF(f)   = YFCTR.L(f)/FS.L(f) ;
 RENTAL(i)  = (WFDIST(i,"capital")*WF.L("capital")*FDSC.L(i,"capital"))
               /FDSC.L(i,"capital") ;
 RDIST(i)   = RENTAL(i)/AVGWF("capital") ;
 VALADD(i)  = (PVA.L(i)+(ITAX(i)*PX.L(i)))*XD.L(i);
 SECTORY(i) = (PVA.L(i))*XD.L(i);
 RMD(i)     = M.L(i)/XXD.L(i) ;

 DISPLAY AVGWF,AVGPROFIT,VALADD,SECTORY ;

 FACTORS(i,"YF")      = SUM(f,YF(i,f)) ;
 FACTORS(i,"YFCAP")   = YF(i,"capital") ;
 FACTORS(i,"PROFIT")  = PROFIT(i) ;
 FACTORS(i,"RENTAL")  = RENTAL(i) ;
 FACTORS(i,"RDIST")   = RDIST(i) ;
 FACTORS(i,"WDCAP")   = WFDIST(i,"CAPITAL") ;
 FACTORS(i,"YFLABOR") = YF(i,"LABOR") ;
 FACTORS(i,"WDLABOR") = WFDIST(i,"LABOR") ;
 FACTORS(i,"YFLAND")  = YF(i,"LAND") ;
 FACTORS(i,"WDLAND")  = WFDIST(i,"LAND") ;
 FACTORS(i,"PINT")    = PINT(i) ;
 FACTORS(i,"INTINP")  = INTINP(i) ;


 COEFFS(i,"ALPHAL")   = ALPHA(i,"LABOR") ;
 COEFFS(i,"ALPHAP")   = ALPHA(i,"LAND") ;
 COEFFS(i,"ALPHAC")   = ALPHA(i,"CAPITAL") ;
 COEFFS(i,"RMD")      = RMD(i) ;
 COEFFS(i,"DELTA")    = DELTA(i) ;
 COEFFS(i,"AD")       = AD(i) ;

 DISPLAY FACTORS, COEFFS ;


*######################################################################


*#### 3) TABLES OF RESULTS FOR RESTART SOLUTION RATIO TABLES

*#### DEFINE SETS FOR RESTART SOLUTION RATIO TABLES ####

* for SCALRES1,SCALRES2,RSCALE
 SET sc / EXR,   PINDEX, RGNP,   GNPVA,  INVEST,   FXDINV,   GDTOT,
          GR,    SSTAX,  TARIFF, INDTAX, ENTTAX,   TOTHHTAX, NETSUB,
          REMIT, GENT,   HHT,    FBOR,   SAVINGS,  ENTSAV,   DEPRECIA,
          HHSAV, GOVSAV, FSAV / ;
 PARAMETER SCALRES1(sc)      AGGREGATE VARIABLES ;
 PARAMETER SCALRES2(sc)      RESTART SCALAR RESULTS ;
 PARAMETER RSCALE(sc)        PERCENT CHANGE FROM BASE SCALARS ;

* for PRICRES
  SET rp / PX, PVA, PE, PWE, PM, PWM, PD, P, PROFIT, RENTAL, PINT / ;
  PARAMETER PRICRES1(i,rp)   PRICE RESULTS BY SECTOR ;
  PARAMETER PRICRES2(i,rp)   RESTART PRICE RESULTS ;
  PARAMETER RPRICE(i,rp)     PERCENT CHANGE FROM BASE PRICE RESULTS ;

* for QUANTRES
  SET rq / XD, VALADD, SECTORY, E, M, LABOR, CAPITAL, LAND, X, XXD / ;
  PARAMETER QUANTRES1(i,rq)  QUANTITY RESULTS BY SECTOR ;
```

```
  PARAMETER QUANTRES2(i,rq)  RESTART QUANTITY RESULTS ;
  PARAMETER RQUANT(i,rq)     PERCENT CHANGE FROM BASE QUANTITY RESULTS ;

*#### SPECIFY TABLES FOR RESTART RATIO SOLUTION REPORTS ####

  PRICRES1(i,"PX")         = PX.L(i) ;
  PRICRES1(i,"PVA")        = PVA.L(i) ;
  PRICRES1(i,"PE")         = PE.L(i) ;
  PRICRES1(i,"PWE")        = PWE.L(i) ;
  PRICRES1(i,"PM")         = PM.L(i) ;
  PRICRES1(i,"PWM")        = PWM(i) ;
  PRICRES1(i,"PD")         = PD.L(i) ;
  PRICRES1(i,"P")          = P.L(i) ;
  PRICRES1(i,"PROFIT")     = PROFIT(i) ;
  PRICRES1(I,"RENTAL")     = RENTAL(i) ;
  PRICRES1(I,"PINT")       = PINT(i) ;

  QUANTRES1(i,"XD")        = XD.L(i) ;
  QUANTRES1(i,"VALADD")    = VALADD(i) ;
  QUANTRES1(i,"SECTORY")   = SECTORY(i) ;
  QUANTRES1(i,"E")         = E.L(i) ;
  QUANTRES1(i,"M")         = M.L(i) ;
  QUANTRES1(i,"LABOR")     = FDSC.L(i,"LABOR") ;
  QUANTRES1(i,"CAPITAL")   = FDSC.L(i,"capital") ;
  QUANTRES1(i,"LAND")      = FDSC.L(i,"LAND") ;
  QUANTRES1(i,"X")         = X.L(i) ;
  QUANTRES1(i,"XXD")       = XXD.L(i) ;

*## MACRO AGGREGATE RESULTS
 SCALRES1("EXR")       = EXR.L ;
 SCALRES1("PINDEX")    = PINDEX.L ;
 SCALRES1("RGNP")      = RGNP.L ;
 SCALRES1("GNPVA")     = GNPVA.L ;

 SCALRES1("INVEST")    = INVEST.L ;
 SCALRES1("FXDINV")    = FXDINV.L ;
 SCALRES1("GDTOT")     = GDTOT.L ;
 SCALRES1("GR")        = GR.L ;

 SCALRES1("SSTAX")     = SSTAX.L ;
 SCALRES1("TARIFF")    = TARIFF.L ;
 SCALRES1("INDTAX")    = INDTAX.L ;
 SCALRES1("ENTTAX")    = ENTTAX.L ;
 SCALRES1("TOTHHTAX")  = TOTHHTAX.L ;
 SCALRES1("NETSUB")    = NETSUB.L ;

 SCALRES1("REMIT")     = REMIT.L ;
 SCALRES1("GENT")      = GENT.L ;
 SCALRES1("HHT")       = HHT.L ;
 SCALRES1("FBOR")      = FBOR.L ;

 SCALRES1("SAVINGS")   = SAVINGS.L ;
 SCALRES1("ENTSAV")    = ENTSAV.L ;
 SCALRES1("DEPRECIA")  = DEPRECIA.L ;
 SCALRES1("HHSAV")     = HHSAV.L ;
 SCALRES1("GOVSAV")    = GOVSAV.L ;
 SCALRES1("FSAV")      = FSAV.L ;

 DISPLAY PRICRES1, QUANTRES1, SCALRES1 ;

*###################### Social Accounting Matrix #####################

 SAM("COMMDTY","ACTIVITY")     = SUM(i,(P.L(i)*INT.L(i))) ;
 SAM("COMMDTY","HOUSEHOLDS")   = SUM(i,(P.L(i)*CD.L(i))) ;
 SAM("COMMDTY","KACCOUNT")     = SUM(i,(P.L(i)*(DST.L(i)+ID.L(i)))) ;
 SAM("COMMDTY","GOVT")         = SUM(i,(P.L(i)*GD.L(i))) ;
 SAM("ACTIVITY","WORLD")       = SUM(i,((EXR.L*PWE.L(i))*E.L(i))) ;
 SAM("ACTIVITY","COMMDTY")     = SUM(i,  (PX.L(i)*XD.L(i))
                                       - (PE.L(i)*E.L(i)) ) ;
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```
SAM("ACTIVITY","GOVT")        = NETSUB.L ;
SAM("VALUAD","ACTIVITY")      = SUM(f, YFCTR.L(f)) ;
SAM("INSTTNS","VALUAD")       = SUM(f,YFCTR.L(f)) - SSTAX.L ;
SAM("INSTTNS","GOVT")         = GENT.L ;
SAM("HOUSEHOLDS","INSTTNS")= SUM((ins,hh),SINTYH(hh,ins)*YINST.L(ins));
SAM("HOUSEHOLDS","GOVT")      = HHT.L ;
SAM("KACCOUNT","INSTTNS")     = ENTSAV.L + DEPRECIA.L ;
SAM("KACCOUNT","HOUSEHOLDS") = HHSAV.L ;
SAM("KACCOUNT","GOVT")        = GOVSAV.L ;
SAM("GOVT","commdty")         = TARIFF.L ;
SAM("GOVT","ACTIVITY")        = INDTAX.L ;
SAM("GOVT","VALUAD")          = SSTAX.L ;
SAM("GOVT","INSTTNS")         = ENTTAX.L ;
SAM("GOVT","HOUSEHOLDS")      = TOTHHTAX.L ;
SAM("WORLD","COMMDTY")        = SUM(i,((PWM(i)*EXR.L)*M.L(i))) ;
SAM("WORLD","HOUSEHOLDS")     = - REMIT.L*EXR.L ;
SAM("WORLD","GOVT")           = - FBOR.L*EXR.L ;
SAM("WORLD","KACCOUNT")       = - FSAV.L*EXR.L ;
SAM("TOTAL","COMMDTY")        = SUM(isam2,SAM(isam2,"COMMDTY")) ;
SAM("TOTAL","ACTIVITY")       = SUM(isam2,SAM(isam2,"ACTIVITY")) ;
SAM("TOTAL","VALUAD")         = SUM(isam2,SAM(isam2,"VALUAD")) ;
SAM("TOTAL","INSTTNS")        = SUM(isam2,SAM(isam2,"INSTTNS")) ;
SAM("TOTAL","HOUSEHOLDS")     = SUM(isam2,SAM(isam2,"HOUSEHOLDS")) ;
SAM("TOTAL","KACCOUNT")       = SUM(isam2,SAM(isam2,"KACCOUNT")) ;
SAM("TOTAL","GOVT")           = SUM(isam2,SAM(isam2,"GOVT")) ;
SAM("total","WORLD")          = SUM(isam2,SAM(isam2,"WORLD")) ;
SAM(isam3,"TOTAL")            = SUM(isam2,SAM(isam3,isam2)) ;

option decimals=3 ;
DISPLAY SAM;

*############################# THE END ################################
```

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COMPILATION TIME     =       10.050 SECONDS        VER: 386-EK-008
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```
----     556 PARAMETER WFDIST          FACTOR PRICE SECTORAL PROPORTIONALITY CONSTANTS

              LABOR      CAPITAL        LAND

LVSTK         0.585        0.401
EXPCRP        0.432        0.852        0.896
OTHCRP        0.501        0.899        1.415
AGPROC        0.929        2.313
AGINP         1.156        1.111
INTMNF        1.384        1.285
FDMNF         1.346        1.087
TRDTRN        0.898        1.325
SERVICE       0.956        0.814
RESTA         0.563        1.464


----     556 PARAMETER WFO             FACTOR PRICE

LABOR    19.733,    CAPITAL  0.157,    LAND     0.053


----     556 PARAMETER FSO             FACTOR SUPPLY

LABOR     96.641,    CAPITAL 6244.072,    LAND     428.250


----     556 PARAMETER YFSECTO         FACTOR INCOME BY SECTOR

LVSTK      9.807,    EXPCRP    29.389,    OTHCRP    15.199,    AGPROC    98.626
AGINP     34.223,    INTMNF   269.408,    FDMNF    312.655,    TRDTRN   437.355
SERVICE 1542.043,    RESTA    158.519


----     556 PARAMETER YFCTRO          FACTOR INCOME SUMMED OVER SECTOR

LABOR    1907.000,    CAPITAL  977.319,    LAND      22.905


----     557 PARAMETER YINSTO          INSTITUTIONAL INCOME

LABR 1637.465,    ENT    558.575,    PROP   22.905


----     557 PARAMETER YHO             HOUSEHOLD INCOME

HHTRN  396.250,    HHLAB 1637.465,    HHCAP  580.231


----     557 PARAMETER MPSO            HOUSEHOLD MARGINAL PROPENSITY TO SAVE

HHLAB 0.062,    HHCAP 0.174


----     557 PARAMETER HTAX            HOUSEHOLD TAX RATE

HHLAB 0.126,    HHCAP 0.350


----     557 PARAMETER ETR                         =        0.098 ENTERPRISE TAX RATE
             PARAMETER ESR                         =        0.035 ENTERPRISE SAVINGS RATE
             PARAMETER SSTR                        =        0.141 SOCIAL SECURITY TAX RATE


----     571 PARAMETER DELTA           ARMINGTON FUNCTION SHARE PARAMETER
```

```
LVSTK        0.233,    EXPCRP      0.177,    OTHCRP       0.366
AGPROC       0.211,    AGINP       0.042,    INTMNF       0.067
FDMNF        0.152,    TRDTRN      0.004,    SERVICE 2.580477E-9

----    571 PARAMETER AC           ARMINGTON FUNCTION SHIFT PARAMETER

LVSTK   1.420,    EXPCRP  1.297,    OTHCRP  1.773,    AGPROC  1.498,    AGINP   1.269
INTMNF  1.365,    FDMNF   1.563,    TRDTRN  1.022,    SERVICE 1.024,    RESTA   1.000

----    571 PARAMETER RMD          RATIO OF IMPORTS TO DOMESTIC SALES

LVSTK   0.008,    EXPCRP  0.002,    OTHCRP  0.111,    AGPROC  0.071,    AGINP   0.096
INTMNF  0.138,    FDMNF   0.213,    TRDTRN  0.002,    SERVICE 0.019


----    579 PARAMETER GAMMA        CET FUNCTION SHARE PARAMETER

LVSTK   1.000,    EXPCRP  0.568,    OTHCRP  0.802,    AGPROC  0.819,    AGINP   0.781
INTMNF  0.788,    FDMNF   0.778,    TRDTRN  0.818,    SERVICE 0.995,    RESTA   0.998


----    579 PARAMETER AT           CET FUNCTION SHIFT PARAMETER

LVSTK   51.023,    EXPCRP   2.074,    OTHCRP   3.006,    AGPROC   3.175
AGINP    2.823,    INTMNF   2.876,    FDMNF    2.612,    TRDTRN   3.162
SERVICE  7.365,    RESTA   10.406


----    584 PARAMETER ALPHA        FACTOR SHARE PARAMETER-PRODUCTION FUNCTION

              LABOR     CAPITAL        LAND

LVSTK         0.489       0.511
EXPCRP        0.113       0.328       0.559
OTHCRP        0.323       0.251       0.427
AGPROC        0.667       0.333
AGINP         0.592       0.408
INTMNF        0.571       0.429
FDMNF         0.841       0.159
TRDTRN        0.755       0.245
SERVICE       0.680       0.320
RESTA         0.075       0.925


----    591 PARAMETER AD           PRODUCTION FUNCTION SHIFT PARAMETER

LVSTK   12.617,    EXPCRP   0.751,    OTHCRP   2.182,    AGPROC  37.138
AGINP   47.468,    INTMNF  16.892,    FDMNF   48.285,    TRDTRN  18.680
SERVICE 12.075,    RESTA    0.583


----    591 PARAMETER QD           DUMMY VARIABLE FOR COMPUTING AD(I)

LVSTK     6.112,    EXPCRP   95.520,    OTHCRP   12.165,    AGPROC   10.532
AGINP     5.589,    INTMNF   40.951,    FDMNF    16.933,    TRDTRN   42.026
SERVICE 216.065,    RESTA   395.827


----    591 PARAMETER FDO          FACTOR DEMAND

LABOR     96.641,    CAPITAL 6244.073,    LAND     428.251


----    597 PARAMETER XDO          DOMESTIC OUTPUT

LVSTK     77.115,    EXPCRP    71.773,    OTHCRP    26.544,    AGPROC   391.145
AGINP    265.280,    INTMNF   691.753,    FDMNF    817.594,    TRDTRN   785.067
SERVICE 2609.047,    RESTA    230.939
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----     597 PARAMETER XO              COMPOSITE GOOD SUPPLY

LVSTK     77.557,    EXPCRP    53.983,    OTHCRP    27.809,    AGPROC   399.482
AGINP    269.608,    INTMNF   734.080,    FDMNF    861.036,    TRDTRN   749.789
SERVICE 2549.723,    RESTA    225.490


----     597 PARAMETER XXDO            DOMESTIC SALES

LVSTK     76.904,    EXPCRP    53.866,    OTHCRP    25.026,    AGPROC   372.919
AGINP    245.939,    INTMNF   644.884,    FDMNF    709.591,    TRDTRN   747.944
SERVICE 2501.795,    RESTA    225.490

----     598 PARAMETER PVAO            VALUE ADDED PRICE BY SECTOR

LVSTK   0.127,    EXPCRP  0.409,    OTHCRP  0.573,    AGPROC  0.252,    AGINP   0.129
INTMNF  0.389,    FDMNF   0.382,    TRDTRN  0.557,    SERVICE 0.591,    RESTA   0.686

----     598 PARAMETER PDO             DOMESTIC GOODS PRICE

LVSTK   1.000,    EXPCRP  1.000,    OTHCRP  1.000,    AGPROC  1.000,    AGINP   1.000
INTMNF  1.000,    FDMNF   1.000,    TRDTRN  1.000,    SERVICE 1.000,    RESTA   1.000


----     598 PARAMETER PEO             DOMESTIC PRICE OF EXPORTS

LVSTK   1.000,    EXPCRP  1.000,    OTHCRP  1.000,    AGPROC  1.000,    AGINP   1.000
INTMNF  1.000,    FDMNF   1.000,    TRDTRN  1.000,    SERVICE 1.000,    RESTA   1.000


----     598 PARAMETER PWEO            WORLD PRICE OF EXPORTS

LVSTK   1.000,    EXPCRP  1.000,    OTHCRP  1.000,    AGPROC  1.000,    AGINP   1.000
INTMNF  1.000,    FDMNF   1.000,    TRDTRN  1.000,    SERVICE 1.000,    RESTA   1.000


----     598 PARAMETER PMO             DOMESTIC PRICE OF IMPORTS

LVSTK   1.000,    EXPCRP  1.000,    OTHCRP  1.000,    AGPROC  1.000,    AGINP   1.000
INTMNF  1.000,    FDMNF   1.000,    TRDTRN  1.000,    SERVICE 1.000,    RESTA   1.000


----     598 PARAMETER PWM             WORLD MARKET PRICE OF IMPORTS (IN DOLLARS)

LVSTK   0.987,    EXPCRP  0.972,    OTHCRP  0.964,    AGPROC  0.897,    AGINP   0.997
INTMNF  0.982,    FDMNF   0.973,    TRDTRN  0.973,    SERVICE 1.000,    RESTA   1.000


----     598 PARAMETER TM              TARIFF RATES ON IMPORTS

LVSTK          0.014,    EXPCRP         0.029,    OTHCRP          0.037
AGPROC         0.115,    AGINP          0.003,    INTMNF          0.018
FDMNF          0.027,    TRDTRN         0.027,    SERVICE 8.345875E-6


----     598 PARAMETER PWTS            PRICE INDEX WEIGHTS

LVSTK   0.013,    EXPCRP  0.012,    OTHCRP  0.004,    AGPROC  0.066,    AGINP   0.044
INTMNF  0.116,    FDMNF   0.137,    TRDTRN  0.132,    SERVICE 0.437,    RESTA   0.039


----     744 VARIABLE  YFCTR.L         FACTOR INCOME
                                       (BILL $)

LABOR   1907.000,    CAPITAL  977.319,    LAND       22.905


----     744 VARIABLE  YINST.L         INSTITUTIONAL INCOME
                                       (BILL $)
```

```
LABR 1637.465,    ENT   558.575,    PROP   22.905


----     744 VARIABLE  YH.L          HOUSEHOLD INCOME
                                     (BILL $)

HHTRN  396.250,    HHLAB 1637.465,    HHCAP  580.231


----     744 VARIABLE  GNPVA.L              =     3166.001 VALUE ADDED IN MARKET
                                                           PRICES GNP
                                                           (BILL $)
             VARIABLE  RGNP.L               =     3166.002 REAL GNP
                                                                            (82 BILL
                                                           $)
             VARIABLE  PINDEX.L             =        1.000 GNP DEFLATOR


----     745 VARIABLE  INT.L         INTERMEDIATES USES                           (82
                                     BILL $)

LVSTK    70.466,    EXPCRP   46.071,    OTHCRP   15.768,    AGPROC  160.111
AGINP   195.025,    INTMNF  694.450,    FDMNF   389.942,    TRDTRN  337.164
SERVICE 767.737,    RESTA   132.121


----     745 VARIABLE  CD.L          FINAL DEMAND FOR PRIVATE CONSUMPTION         (82
                                     BILL $)

LVSTK      6.597,    EXPCRP     0.914,    OTHCRP    11.488,    AGPROC   231.451
AGINP     55.811,    INTMNF    22.496,    FDMNF    216.391,    TRDTRN   386.724
SERVICE 1041.077,    RESTA     77.752


----     745 VARIABLE  GD.L          FINAL DEMAND FOR GOVERNMENT CONSUMPTION      (82
                                     BILL $)

LVSTK     0.431,    EXPCRP    7.475,    OTHCRP    0.681,    AGPROC    9.138
AGINP    12.500,    INTMNF   12.749,    FDMNF    97.993,    TRDTRN   28.760
SERVICE 465.610,    RESTA     6.364


----     745 VARIABLE  ID.L          FINAL DEMAND FOR PRODUCTIVE INVESTMENT       (82
                                     BILL $)

AGPROC    1.180,    AGINP     8.418,    INTMNF    8.724,    FDMNF   165.525
SERVICE 278.703,    RESTA     9.252


----     745 VARIABLE  DST.L         INVENTORY INVESTMENT BY SECTOR               (82
                                     BILL $)

LVSTK    0.063,    EXPCRP  -0.477,    OTHCRP  -0.129,    AGPROC  -2.399
AGINP   -2.146,    INTMNF  -4.339,    FDMNF   -8.814,    TRDTRN  -2.858
SERVICE -3.402


----     745 VARIABLE  DK.L          VOLUME OF INVESTMENT BY SECTOR OF DESTINATION
                                     (82 BILL $)

LVSTK     6.033,    EXPCRP    5.462,    OTHCRP    2.045,    AGPROC    6.863
AGINP     6.074,    INTMNF   43.421,    FDMNF    22.009,    TRDTRN   38.997
SERVICE 292.551,    RESTA    48.345
```

---- 789 PARAMETER SAM SOCIAL ACCOUNTING MATRIX

	COMMDTY	ACTIVITY	VALUAD	INSTTNS	HOUSEHOLDS	GOVT
COMMDTY		2808.86			2050.70	641.70
ACTIVITY	5604.36					
VALUAD		2907.22				
INSTTNS			2637.69			47.53
HOUSEHOLDS				2218.95		396.25
GOVT	8.60	250.18	269.54	63.08	409.34	
KACCOUNT				403.19	153.91	-110.83
WORLD	335.60				1.25	26.08
TOTAL	5948.56	5966.26	2907.22	2685.22	2615.20	1000.73

+	KACCOUNT	WORLD	TOTAL
COMMDTY	447.30		5948.56
ACTIVITY		361.90	5966.26
VALUAD			2907.22
INSTTNS			2685.22
HOUSEHOLDS			2615.20
GOVT			1000.73
KACCOUNT			446.27
WORLD	-1.03		361.90
TOTAL	446.27	361.90	

```
MODEL STATISTICS

BLOCKS OF EQUATIONS    45     SINGLE EQUATIONS     232
BLOCKS OF VARIABLES    50     SINGLE VARIABLES     260
NON ZERO ELEMENTS    1321     NON LINEAR N-Z       624
DERIVATIVE POOL        23     CONSTANT POOL        233
CODE LENGTH          7354

GENERATION TIME      =       14.550 SECONDS



EXECUTION TIME       =       23.460 SECONDS       VER: 386-EK-008

               S O L V E     S U M M A R Y

     MODEL   US82                 OBJECTIVE  RGNP
     TYPE    NLP                  DIRECTION  MAXIMIZE
     SOLVER  MINOS5               FROM LINE  1048

**** SOLVER STATUS     1 NORMAL COMPLETION
**** MODEL STATUS      2 LOCALLY OPTIMAL
**** OBJECTIVE VALUE             3166.0009

 RESOURCE USAGE, LIMIT         39.000     1000.000
 ITERATION COUNT, LIMIT       195         1000
 EVALUATION ERRORS              0            0

     M I N O S    5.2    (Jun 1989)
     = = = = =

     B. A. Murtagh, University of New South Wales
       and
     P. E. Gill,  W. Murray,  M. A. Saunders and M. H. Wright
     Systems Optimization Laboratory, Stanford University.


 WORK SPACE NEEDED (ESTIMATE)  --   21910 WORDS.
 WORK SPACE ALLOCATED          --   39052 WORDS.

 EXIT -- OPTIMAL SOLUTION FOUND
 MAJOR ITNS, LIMIT               8      50
 FUNOBJ, FUNCON CALLS            0      13
 SUPERBASICS                     0
 INTERPRETER USAGE            0.00
 NORM RG / NORM PI     0.000E+00


**** REPORT SUMMARY :        0     NONOPT
                             0 INFEASIBLE
                             0  UNBOUNDED
                             0     ERRORS
```

---- 1138 PARAMETER SCALRES

EXR	1.000000,	PINDEX	1.000000,	GDTOT	641.700000
INVEST	447.299106,	SSTAX	269.535307,	ENTTAX	63.079604
TOTHHTAX	409.335718,	REMIT	-1.250000,	GENT	47.530000
HHT	396.249995,	FBOR	-26.080000,	ENTSAV	20.030312
HHSAV	153.907905,	GOVSAV	-110.833019,	FSAV	1.029951
RGNP	3166.000916,	GNPVA	3166.000217,	FXDINV	471.800138
GR	974.646839,	TARIFF	8.599994,	INDTAX	250.176203
SAVINGS	447.299106,	DEPRECIA	383.163957		

---- 1138 PARAMETER FCTRES1 FACTOR DEMAND BY SECTOR

	LABOR	CAPITAL	LAND
LVSTK	0.415351	79.843460	
EXPCRP	0.389789	72.291068	342.600644
OTHCRP	0.495859	27.070361	85.649356
AGPROC	3.584818	90.829040	
AGINP	0.887447	80.391815	
INTMNF	5.635198	574.657979	
FDMNF	9.907518	291.267435	
TRDTRN	18.648109	516.105260	
SERVICE	55.605910	3871.779401	
RESTA	1.071000	639.836181	

---- 1138 PARAMETER FCTRES2 MISCELLANEOUS FACTOR VARIABLE RESULTS

	LABOR	CAPITAL	LAND
WF	19.732823	0.156519	0.053486
FS	96.640999	6244.071998	428.250000
YFCTR	1906.999485	977.319011	22.905524

---- 1138 PARAMETER SECTRES SECTORAL QUANTITIES AND PRICES

	LVSTK	EXPCRP	OTHCRP	AGPROC	AGINP	INTMNF
XD	77.114749	71.773227	26.543486	391.146007	265.279442	691.750952
E	0.211589	17.906952	1.517499	18.226625	19.340700	46.868797
M	0.653642	0.116665	2.782435	26.562726	23.669220	89.196029
PX	0.999999	1.000000	1.000002	1.000000	1.000000	1.000000
PE	1.000002	0.999999	1.000001	1.000000	1.000000	1.000000
PM	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
P	0.999999	1.000000	1.000002	1.000000	1.000000	1.000000
PD	0.999999	1.000000	1.000002	1.000000	1.000000	1.000000
PK	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
PVA	0.127177	0.409476	0.572615	0.252146	0.129008	0.389458
PWE	1.000002	1.000000	1.000002	1.000000	1.000000	1.000000
X	77.556803	53.982940	27.808421	399.482108	269.607962	734.078184
XXD	76.903161	53.866275	25.025986	372.919382	245.938742	644.882155
INT	70.466404	46.070617	15.767772	160.111561	195.024743	694.448788
CD	6.597278	0.914244	11.488463	231.451029	55.811001	22.495797
GD	0.430580	7.475156	0.680843	9.137799	12.499662	12.748641
ID				1.180227	8.418136	8.723619
DST	0.062540	-0.477077	-0.128656	-2.398507	-2.145580	-4.338662
DK	6.032910	5.462031	2.045254	6.863278	6.074428	43.421192

+	FDMNF	TRDTRN	SERVICE	RESTA
XD	817.592523	785.067874	2609.047697	230.939457

E	108.002865	37.123250	107.252247	5.449356
M	151.445547	1.845286	47.928278	
PX	1.000000	1.000000	1.000000	1.000000
PE	1.000000	1.000000	1.000000	1.000000
PM	1.000000	1.000000	1.000000	1.000000
P	1.000000	1.000000	1.000000	1.000000
PD	1.000000	1.000000	1.000000	1.000000
PK	1.000000	1.000000	1.000000	1.000000
PVA	0.382409	0.557092	0.591037	0.686410
PWE	1.000000	1.000000	1.000000	1.000000
X	861.035204	749.789910	2549.723727	225.490101
XXD	709.589658	747.944624	2501.795450	225.490101
INT	389.942009	337.163928	767.737187	132.121488
CD	216.390846	386.724090	1041.076569	77.752339
GD	97.992626	28.760324	465.609996	6.364374
ID	165.524188		278.702174	9.251900
DST	-8.814465	-2.858432	-3.402198	
DK	22.008538	38.997121	292.550121	48.345371

---- 1138 PARAMETER INSRES INSTITUTIONAL INCOME RESULTS

	LABR	ENT	PROP
YINST	1637.464178	558.575138	22.905524

---- 1138 PARAMETER HHRES MISCELLANEOUS HOUSEHOLD RESULTS

	HHTRN	HHLAB	HHCAP
MPS		0.061607	0.174295
YH	396.249995	1637.464178	580.230662

----	1251	PARAMETER AGTOTFD	=	100.000	AGRICULTURAL TERMS OF TRADE
		PARAMETER AGTOTVA	=	62.939	AG TERMS OF TRADE VALUE ADDED
		PARAMETER AGTOTM	=	99.345	AG TERMS OF TRADE WORLD IMPORT PRICE
		PARAMETER AGTOTE	=	100.000	AG TERMS OF TRADE WORLD EXPORT PRICE
----	1275	PARAMETER BOT	=	26.300	NOMINAL BALANCE OF TRADE
		PARAMETER BOTR	=	17.700	REAL BALANCE OF TRADE
		PARAMETER NEX	=	361.900	NOMINAL EXPORTS
		PARAMETER ESUM	=	361.900	REAL EXPORTS
		PARAMETER NIM	=	335.600	NOMINAL IMPORTS
		PARAMETER MSUM	=	344.200	REAL IMPORTS
		PARAMETER SHCONSUMP	=	64.773	CONSUMPTION SHARE OF NOMINAL GNP
		PARAMETER SHINVEST	=	14.128	INVESTMENT SHARE OF NOMINAL GNP
		PARAMETER SHGDTOT	=	20.268	GOVT CONSUMPTION SHARE OF NOMINAL GNP
		PARAMETER SHEX	=	11.431	EXPORT SHARE OF NOMINAL GNP
		PARAMETER SHIM	=	10.600	IMPORT SHARE OF NOMINAL GNP
		PARAMETER SHBOT	=	0.831	BALANCE OF TRADE SHARE OF NOMINAL GNP
		PARAMETER SHFSAV	=	0.230	FOREIGN SAVING SHARE OF INVESTMENT
		PARAMETER SHGSAV	=	-24.778	GOVERNMENT SAVING SHARE OF INVESTMENT
		PARAMETER SHPSAV	=	124.548	PRIVATE SAVING SHARE OF INVESTMENT
----	1297	PARAMETER COLIND	=	100.000	COST OF LIVING INDEX
		PARAMETER EXRIND	=	100.000	REAL EXCHANGE RATE INDEX
		PARAMETER NGNP	=	3166.000	NOMINAL GNP
		PARAMETER PDIND	=	100.000	DOMESTIC SUPPLY PRICE INDEX
		PARAMETER PIND	=	100.000	COMPOSITE GOOD PRICE INDEX

PARAMETER PEIND = 100.000 DOMESTIC EXPORT PRICE INDEX
PARAMETER PMIND = 100.000 DOMESTIC IMPORT PRICE INDEX
PARAMETER PWEIND = 100.000 WORLD EXPORT PRICE INDEX
PARAMETER PWMIND = 97.501 WORLD IMPORT PRICE INDEX
PARAMETER PXIND = 100.000 PRODUCER PRICE INDEX

---- 1349 PARAMETER GNPTAB GNP ACCOUNTS

	NOMINAL	REAL	NOMSHARE	REALSHARE	DEFLATOR
CONSMPT	2050.701	2050.702	64.773	64.773	100.000
INVESTMENT	471.800	471.800	14.902	14.902	100.000
INVENTORY	-24.501	-24.501	-0.774	-0.774	100.000
GOVERNMENT	641.700	641.700	20.268	20.268	100.000
EXPORTS	361.900	361.900	11.431	11.431	100.000
IMPORTS	-335.600	-335.600	-10.600	-10.600	100.000
GNP	3166.000	3166.001	100.000	100.000	100.000

---- 1349 PARAMETER GNPTAB2 SECTORAL VALUE ADDED

	NOMINAL	REAL	NOMSHARE	REALSHARE	DEFLATOR
LVSTK	11.176	11.176	0.353	0.353	99.999
EXPCRP	30.666	30.666	0.969	0.969	100.000
OTHCRP	15.585	15.585	0.492	0.492	100.000
AGPROC	109.400	109.400	3.455	3.455	100.000
AGINP	40.316	40.316	1.273	1.273	100.000
INTMNF	296.374	296.374	9.361	9.361	100.000
FDMNF	322.350	322.351	10.182	10.182	100.000
TRDTRN	513.082	513.082	16.206	16.206	100.000
SERVICE	1638.117	1638.117	51.741	51.741	100.000
RESTA	188.934	188.934	5.968	5.968	100.000

---- 1349 PARAMETER SUMGNP AGGREGATE GNP

NOMINAL 3166.000, REAL 3166.001, NOMSHARE 100.000
REALSHARE 100.000

---- 1349 PARAMETER GNPRATIO = 1.000 GNP VALUE ADDED CORRECTION FACTOR

---- 1379 PARAMETER ABSORB ABSORPTION TABLE (REAL)

	E	M	GNP	C	I	G
TOTAL	361.900	344.200	3166.001	2050.702	471.800	641.700
AG	19.636	3.553	43.127	19.000		8.587
NON-AG	342.264	340.647	3122.874	2031.702	471.800	633.113

+	NETE-M	T-G	ABSORB
TOTAL	17.700	-110.833	3164.202
AG	16.083		27.587
NON-AG	1.617		3136.615

---- 1398 PARAMETER AVGWF AVERAGE FACTOR PRICE CURRENT WEIGHTS

LABOR 19.733, CAPITAL 0.157, LAND 0.053

---- 1398 PARAMETER AVGPROFIT = 0.157 AVERAGE PROFIT RATE

---- 1398 PARAMETER VALADD VALUE ADDED AT MARKET PRICE

LVSTK	11.176,	EXPCRP	30.666,	OTHCRP	15.585,	AGPROC	109.400
AGINP	40.316,	INTMNF	296.374,	FDMNF	322.350,	TRDTRN	513.082
SERVICE	1629.517,	RESTA	188.934				

---- 1398 PARAMETER SECTORY VALUE ADDED AT FACTOR COST

LVSTK	9.807,	EXPCRP	29.389,	OTHCRP	15.199,	AGPROC	98.626
AGINP	34.223,	INTMNF	269.408,	FDMNF	312.654,	TRDTRN	437.355
SERVICE	1542.043,	RESTA	158.519				

---- 1421 PARAMETER FACTORS FACTOR RETURNS DISTRIBUTIVE PARAMETERS

	YF	YFCAP	PROFIT	RENTAL	RDIST	WDCAP
LVSTK	9.807	5.015	0.063	0.063	0.401	0.401
EXPCRP	29.389	9.644	0.133	0.133	0.852	0.852
OTHCRP	15.199	3.808	0.141	0.141	0.899	0.899
AGPROC	98.626	32.884	0.362	0.362	2.313	2.313
AGINP	34.223	13.975	0.174	0.174	1.111	1.111
INTMNF	269.408	115.536	0.201	0.201	1.285	1.285
FDMNF	312.654	49.561	0.170	0.170	1.087	1.087
TRDTRN	437.355	107.022	0.207	0.207	1.325	1.325
SERVICE	1542.043	493.262	0.127	0.127	0.814	0.814
RESTA	158.519	146.611	0.229	0.229	1.464	1.464

+	YFLABOR	WDLABOR	YFLAND	WDLAND	PINT	INTINP
LVSTK	4.793	0.585			0.855	65.939
EXPCRP	3.324	0.432	16.421	0.896	0.573	41.108
OTHCRP	4.907	0.501	6.484	1.415	0.413	10.958
AGPROC	65.741	0.929			0.720	281.746
AGINP	20.248	1.156			0.848	224.964
INTMNF	153.872	1.384			0.572	395.377
FDMNF	263.093	1.346			0.606	495.242
TRDTRN	330.333	0.898			0.346	271.986
SERVICE	1048.781	0.956			0.375	979.530
RESTA	11.908	0.563			0.182	42.005

---- 1421 PARAMETER COEFFS SHIFT

	ALPHAL	ALPHAC	ALPHAP	RMD	DELTA	AD
LVSTK	0.489	0.511		0.008	0.233	12.617
EXPCRP	0.113	0.328	0.559	0.002	0.177	0.751
OTHCRP	0.323	0.251	0.427	0.111	0.366	2.182
AGPROC	0.667	0.333		0.071	0.211	37.138
AGINP	0.592	0.408		0.096	0.042	47.468
INTMNF	0.571	0.429		0.138	0.067	16.892
FDMNF	0.841	0.159		0.213	0.152	48.285
TRDTRN	0.755	0.245		0.002	0.004	18.680
SERVICE	0.680	0.320		0.019	2.580477E-9	12.075
RESTA	0.075	0.925				0.583

---- 1507 PARAMETER PRICRES1 PRICE RESULTS BY SECTOR

	PX	PE	PM	P	PD	PVA
LVSTK	1.000	1.000	1.000	1.000	1.000	0.127
EXPCRP	1.000	1.000	1.000	1.000	1.000	0.409
OTHCRP	1.000	1.000	1.000	1.000	1.000	0.573
AGPROC	1.000	1.000	1.000	1.000	1.000	0.252
AGINP	1.000	1.000	1.000	1.000	1.000	0.129
INTMNF	1.000	1.000	1.000	1.000	1.000	0.389

FDMNF	1.000	1.000	1.000	1.000	1.000	0.382
TRDTRN	1.000	1.000	1.000	1.000	1.000	0.557
SERVICE	1.000	1.000	1.000	1.000	1.000	0.591
RESTA	1.000	1.000	1.000	1.000	1.000	0.686

+	PWE	PROFIT	RENTAL	PINT	PWM
LVSTK	1.000	0.063	0.063	0.855	0.987
EXPCRP	1.000	0.133	0.133	0.573	0.972
OTHCRP	1.000	0.141	0.141	0.413	0.964
AGPROC	1.000	0.362	0.362	0.720	0.897
AGINP	1.000	0.174	0.174	0.848	0.997
INTMNF	1.000	0.201	0.201	0.572	0.982
FDMNF	1.000	0.170	0.170	0.606	0.973
TRDTRN	1.000	0.207	0.207	0.346	0.973
SERVICE	1.000	0.127	0.127	0.375	1.000
RESTA	1.000	0.229	0.229	0.182	1.000

---- 1507 PARAMETER QUANTRES1 QUANTITY RESULTS BY SECTOR

	LABOR	CAPITAL	LAND	XD	E	M
LVSTK	0.415	79.843		77.115	0.212	0.654
EXPCRP	0.390	72.291	342.601	71.773	17.907	0.117
OTHCRP	0.496	27.070	85.649	26.543	1.517	2.782
AGPROC	3.585	90.829		391.146	18.227	26.563
AGINP	0.887	80.392		265.279	19.341	23.669
INTMNF	5.635	574.658		691.751	46.869	89.196
FDMNF	9.908	291.267		817.593	108.003	151.446
TRDTRN	18.648	516.105		785.068	37.123	1.845
SERVICE	55.606	3871.779		2609.048	107.252	47.928
RESTA	1.071	639.836		230.939	5.449	

+	X	XXD	VALADD	SECTORY
LVSTK	77.557	76.903	11.176	9.807
EXPCRP	53.983	53.866	30.666	29.389
OTHCRP	27.808	25.026	15.585	15.199
AGPROC	399.482	372.919	109.400	98.626
AGINP	269.608	245.939	40.316	34.223
INTMNF	734.078	644.882	296.374	269.408
FDMNF	861.035	709.590	322.350	312.654
TRDTRN	749.790	747.945	513.082	437.355
SERVICE	2549.724	2501.795	1629.517	1542.043
RESTA	225.490	225.490	188.934	158.519

---- 1507 PARAMETER SCALRES1 AGGREGATE VARIABLES

EXR	1.000,	PINDEX	1.000,	GDTOT	641.700,	INVEST	447.299
SSTAX	269.535,	ENTTAX	63.080,	TOTHHTAX	409.336,	REMIT	-1.250
GENT	47.530,	HHT	396.250,	FBOR	-26.080,	ENTSAV	20.030
HHSAV	153.908,	GOVSAV	-110.833,	FSAV	1.030,	RGNP	3166.001
GNPVA	3166.000,	FXDINV	471.800,	GR	974.647,	TARIFF	8.600
INDTAX	250.176,	SAVINGS	447.299,	DEPRECIA	383.164		

---- 1547 PARAMETER SAM SOCIAL ACCOUNTING MATRIX

	COMMDTY	ACTIVITY	VALUAD	INSTTNS	HOUSEHOLDS	GOVT
COMMDTY		2808.854			2050.701	641.700
ACTIVITY	5604.354					
VALUAD		2907.224				
INSTTNS			2637.689			47.530
HOUSEHOLDS				2218.945		396.250
GOVT	8.600	250.176	269.535	63.080	409.336	
KACCOUNT				403.194	153.908	-110.833
WORLD	335.600				1.250	26.080
TOTAL	5948.554	5966.254	2907.224	2685.219	2615.195	1000.727

+	KACCOUNT	WORLD	TOTAL
COMMDTY	447.299		5948.554
ACTIVITY		361.900	5966.254
VALUAD			2907.224
INSTTNS			2685.219
HOUSEHOLDS			2615.195
GOVT			1000.727
KACCOUNT			446.269
WORLD	-1.030		361.900
TOTAL	446.269	361.900	

**** FILE SUMMARY

INPUT G:\US82.GMS
OUTPUT G:\US82.LST

EXECUTION TIME = 12.140 SECONDS VER: 386-EK-008

*U.S.GOVERNMENT PRINTING OFFICE:1990-261-420:20522/ER

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